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FINAL TECHNICAL REPORT
for
RADIO TRANSMITTING SET AN/FRT-33 (XC-1)

PERIOD
May 1954 through June 1958

Contract No. DA - 36 - 039 SC - 64441

DA Project No. 3 - 24 - 01 - 071

SC Project No. 807 A

Placed By
LABORATORY PROCUREMENT OFFICE
SIGNAL CORPS SUPPLY AGENCY
FORT MONMOUTH, NEW JERSEY

62-1-2 XON

Continental Electronics
MANUFACTURING COMPANY
4212 S. Buckner Blvd DALLAS 27, TEXAS

FINAL TECHNICAL REPORT

for

RADIO TRANSMITTING SET AN/FRT-33 (XC-1)

Period - May 1954 through June 1958

Object - Development of amplifier equipment suitable for long distance communications with normal power output of 300 kilowatts over a frequency range of 4 to 30 mc. Modification of Radio Transmitting Set AN/FRT-22 for use as driver equipment for this amplifier equipment.

SC Contract No. DA-36-039 SC-64441

SC Specification No. SCL-1517; 8 February, 1954

DA Project No. 3-24-01-071

SC Project No. 807 A

Report Prepared by W. D. Mitchell

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PURPOSE

This contract provided for the development of an amplifier, capable of long range communications, having a nominal cw output of 300-kw average power and a minimum of 300-kw peak power for single-side-band communications systems. The frequency range of this equipment was specified to be 4 to 30 mc without a gap and to have a 1% overlap at the ends of the range. Radio Transmitting Set AN/FRT-22 was to be modified for use as a driver for this 300-kw transmitter. The AN/FRT-22 was to be excited by the Radio Transmitting Set T-409/FRC-30 to complete the amplifier grouping. An untuned-loop balun capable of operating at 300-kw average power, 600-kw peak power over a frequency range of 4 to 30 mc had to be developed to provide a balanced output. The work to be accomplished was originally divided into three groups. Group One deals with the modification of Radio Transmitting Set AN/FRT-22; Group Two involves the design of the 300-kw amplifier section; and Group Three concerns the design and construction of the 40-kw amplifier of the radio transmitting set AN/FRT-22, as authorized in Article I, Item 2, Note 7, of Contract No. DA-36-039 SC-64441. Each group is broken down into one or more parts.

Group One - Modification of Radio Transmitting Set AN/FRT-22.

Part (a) of Group One deals with the alteration of the frequency range of the Radio Transmitting Set AN/FRT-22 to extend its coverage from the original 4 to 26.5 mc to the new 4 to 30 mc frequency range without a gap and to have a 1% overlap at the upper end of the range.

Part (b) of Group One calls for the rearrangement of the protective functions of the 40-kw section of the driver amplifier controls to allow coordination with the equivalent functions of the

300-kw power amplifier and at the same time preserve the original functions so that the 40-kw section can be used in the normal way after dissociation of the 300-kw power amplifier.

Part (c) of Group One involves the interlocking of the automatic re-start circuits of the 40-kw amplifier with those of the 300-kw equipment so that the proper sequence of operation will follow through automatically without damage to either equipment.

Group Two - The 300-Kw HF Amplifier Group.

Part (a) of Group Two involves the design and construction of an output network capable of operating at the 300-kw power level and arranged so that it can be attached to a two-wire balanced-to-ground transmission line having a nominal impedance of 600-ohms and a vswr not in excess of 2 to 1. (The Signal Corps Research Projects provided information that later changed the transmission line impedance from 600-ohms, as stated above, first to 300-ohms and then to 440-ohms.)

Part (b) of Group Two covers the design and construction of an amplifier having a nominal output power of 300-kw and arranged for connection to the output network covered by Part (a) of this group. This amplifier was to be fed by a 40-kw source which may be either Radio Transmitting Set AN/FRT-22 or any other amplifier of similar design having an output power of 40-kw. All controls and protective devices of the 300-kw amplifier must be properly engineered and integrated to any other driving equipment before a satisfactory arrangement can be evolved.

Part (c) of Group Two involves the design and construction of the required power supply and control equipment for the 300-kw

amplifier and the necessary arrangement for connecting to the existing control circuits of Radio Transmitting Set AN/FRT-22. This power supply was to have a nominal output voltage of 18-kv at 35 amperes dc.

Part (d) of Group Two concerns the water cooling system which was not required in the original specifications but which is required as a result of the choice of power amplifier tubes. The original concept was to provide, or consider for provision, a water cooled driving stage, since a water-to-air heat exchanger was required for the power amplifier stage. This was not the case since an air cooled tube was chosen for the 40-kw alternate amplifier stage of the equipment.

Group Three - The 40-Kw Alternate Amplifier.

Part (a) of Group Three concerns the design and construction of a 40-kw alternate amplifier. This amplifier was to be capable of operation over the same frequency band as the 300-kw amplifier and was to be designed to do so when driven from a suitable source.

Part (b) of Group Three involves the design of a suitable power and control arrangement to be a power source of 8-kv for the 40-kw alternate amplifier. This suggested 8-kv nominal power supply was changed to 9-kv at a later date.

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ABSTRACT

This report covers the technical aspects of the development of Radio Transmitting Set AN/FRT-33 (XC-1) on a task by task or phase by phase basis. This equipment is an amplifier capable of long range communications, rated at a nominal cw output of 300-kw average power and a minimum of 300-kw peak power for single-sideband communications systems. The problems encountered during the development of the equipment are stated, and the solutions to those problems are described in detail. The Radio Transmitting Set AN/FRT-22, excited by Radio Transmitting Set T-409/FRC-30, was modified to extend the operating frequency range to 4 to 30 mc, without a gap, and to have a 1% overlap at the ends of the range. It was used as a driver for the 300-kw amplifier. The protective functions of the 40-kw section of the driver controls were rearranged and coordinated with the equivalent functions of the 300-kw equipment. The automatic re-start circuits of the 40-kw amplifier were interlocked with those of the 300-kw amplifier to assure correct sequential operation of all functions of the equipment. The original conception of the design of the 300-kw output network progressed through several stages of development during which problems of the design were examined, evaluated and eliminated to produce the final configuration of a 25 to 50-ohm "L" matching single-ended network which required a 50 to 220-ohm balun device capable of operation at a 2 to 1 vswr. Design problems due to circuit complexities ascribed to tuned baluns caused a dual study of untuned baluns to be initiated. A parallel wound transmission line balun and a loop balun were considered. An untuned loop balun capable of operating at 300-kw average power and 600-kw peak power over a frequency range of 4 to 30 mc

was designed, fabricated and power tested for use with the associated output network. An amplifier with a nominal output of 300-kw was designed and constructed. This 300-kw amplifier could be driven by Radio Transmitting Set AN/FRT-22, or by any other similar amplifier providing an output power of 40-kw. All control and protective devices of the 300-kw equipment were engineered to be integrated with the driving equipment. The physical rearrangement of the output network was changed to shorten the transmission line between the power amplifier and the output network, thereby minimizing the difficulties encountered with respect to harmonic output. The design and construction of an 18-kv, 35-ampere dc power supply for the 300-kw amplifier included the necessary arrangements for connecting to the existing control circuits of the Radio Transmitting Set AN/FRT-22. The 300-kw power amplifier was water cooled. Water cooling of the driver stage was originally intended, but an air cooled tube was selected for use in the 40-kw alternate amplifier. A 40-kw alternate amplifier was designed and constructed which was capable of operating over the same frequency band as the 300-kw amplifier. An 8-kv power supply was designed to provide the power for the 40-kw amplifier. The Signal Corps proposed using existing 8-kv power supply to provide the required potentials for the 40-kw alternate amplifier. This was not feasible because a power supply capable of producing 9-kv was required to power the 40-kw alternate amplifier. The suggested 8-kv nominal power supply was later redesigned and changed to 9-kv.

PUBLICATIONS

A 600 Kilowatt High Frequency Amplifier

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Continental Electronics Mfg. Co.
Dallas, Texas

A description is given of the electrical circuits and mechanical construction of a power amplifier designed primarily for use in single sideband suppressed carrier operation having a peak envelope power output of 600,000 watts. The amplifier is also designed to handle an off-on keyed CW signal or frequency shift keyed signal at a continuous power output of 300,000 watts. Some of its features are continuous range motor tuning of all circuit elements over the frequency range from 4 to 30 megacycles, a unique method of opening the amplifier by motor elevation of the plate section and a sliding drawer grid section for tube removal and a fault amplifier type of protective system using a hydrogen thyratron to short-circuit the high voltage rectifier in case of internal arcing in the power amplifier tube.

The power amplifier uses a single tube. The gain in linear operation with resistance loading on the grid circuit is approximately 40.

This amplifier was originally developed under a Signal Corps development contract.

The Amplifier to be described was developed to operate in a frequency range from 4 to 30 megacycles as a linear amplifier for use in single sideband suppressed carrier service with a peak envelope power output of 600 kilowatts and an average power output of 300 kilowatts. The work was authorized under a U. S. Signal Corps developmental contract administered by Coles Laboratory at Ft. Monmouth, New Jersey.

The equipment includes an 18 kilovolt, 40 ampere rectifier, a filter system for this rectifier, a power distribution switchboard, a control unit for the amplifier, a water cooling system, the amplifier unit itself, and another cubicle containing an output matching network.

This photograph (Figure 1) shows a front view of the cubicles which assemble to form a portion of the front panel of the equipment. From left to right, the units are rectifier tube assembly No. 1, rectifier tube assembly No. 2, the transmitter control unit, and a portion of the power amplifier. The output matching network unit not shown in this photograph is located on the right-hand side of the power amplifier unit.

Figure 2 shows a front view of the power distribution unit which contains the plate circuit control breakers, the master circuit breaker, and protective breakers for feeding the auxiliary circuits of the transmitter.

Figure 3 shows the filter capacitor rack which together with the filter choke comprises the 18 kilovolt rectifier filter system. The filter capacitors are in the lower shelf of the rack and included with them is a motor operated grounding switch and various surge resistors used to limit charging current to the filter capacitor bank and to limit fault current in case of an arc-over in the power amplifier.

Since the auxiliary units are more or less conventional, this description will be restricted to the amplifier itself.

Power Amplifier

The power amplifier is housed in a single cubicle 54 inches wide by 72 inches deep and 78 inches high. (Figure 4)

As in the other units, a meter panel is provided at the top and controls are located on the two side panels at either side of the access door.

The power amplifier uses a single RCA Type 2332C, ceramic sealed, beam triode. (Figure 5). This tube has a plate dissipation rating of 500 kilowatts and is operated in this amplifier with a plate loss of approximately 300 kilowatts. The DC plate potential applied for full power operation is 18,000 volts, and a fixed bias for linear operation of 300 to 325 volts is used. This tube uses a thoriated tungsten filament and the filament and grid wires are assembled on a specially designed beam-forming cylinder which effectively shields the grid from the anode. The electron optical principles applied result in a very low grid current and high power gain.

Water cooling is required at four points on this tube. Approximately 80 gallons per

minute is circulated through the anode water jacket. Water is also circulated through internal ducts in the beam-forming cylinder. In addition, a water cooling ring is bolted to the grid ring of the tube and also to the upper cathode radio frequency connection.

The filament heating current is 1000 amperes at 7.3 volts.

As a result of the grid shielding provided by the beam-forming cylinder, the grid-to-plate capacity of this tube is only 13 micro-microfarads. The anode-to-cathode capacity is 160 micromicrofarads. Because of the close spacing by which the grid wires are held on the beam-forming cylinder, the capacity from grid to cathode is 1400 micromicrofarads. At 30 megacycles this gives an input reactance of less than 4 ohms. When operating at 600 kilowatts peak envelope output power, the average grid drive voltage is approximately 950 volts RMS. This voltage applied across the low reactance input results in a reactive current flow to the grid of about 250 amperes.

This low reactance input establishes a limitation on the structure of the input circuit since at 30 megacycles, an inductance of two one hundredths of a microhenry will resonate the input capacity.

In the plate circuit the plate-to-cathode capacity plus stray capacities inherent in the circuitry limit the external inductance for resonance at 30 megacycles to approximately 1/10 of one microhenry.

For 30 megacycle operation a coaxial cavity or some adaptation of such a cavity would provide a simple and quite suitable arrangement for both the input and output circuit of the amplifier (Figure 6). However, in this application, the specification requires that these circuits be continuously tuned by motors from 30 down to 4 megacycles with no stepping switches to alter the circuitry or switch in lumped components. A design was therefore required which provides lumped component circuits for both the input and output of the tube with such circuitry placed sufficiently close to the tube and so designed that lead inductances will not prevent operation at 30 megacycles. When this is done, a major mechanical problem develops

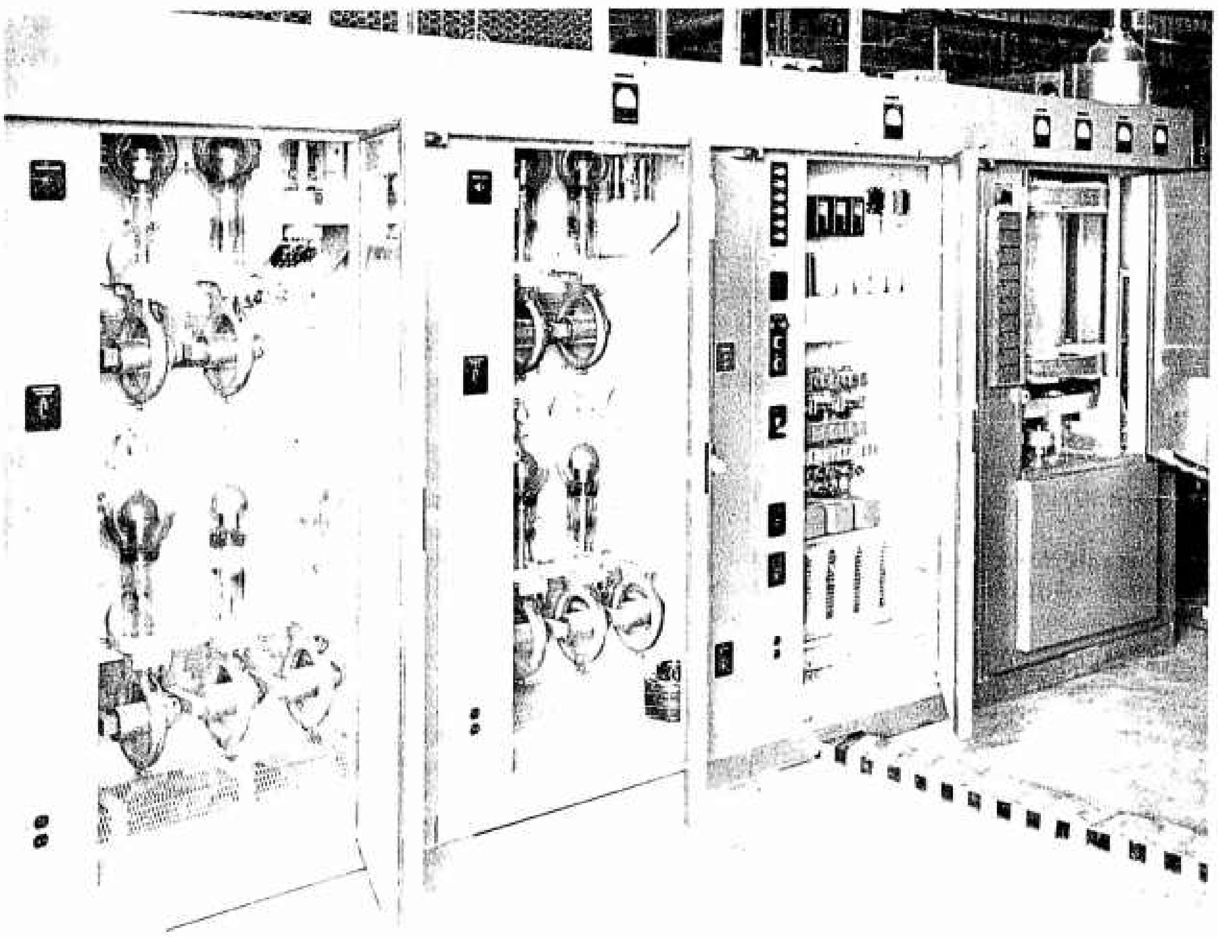


Fig. 1

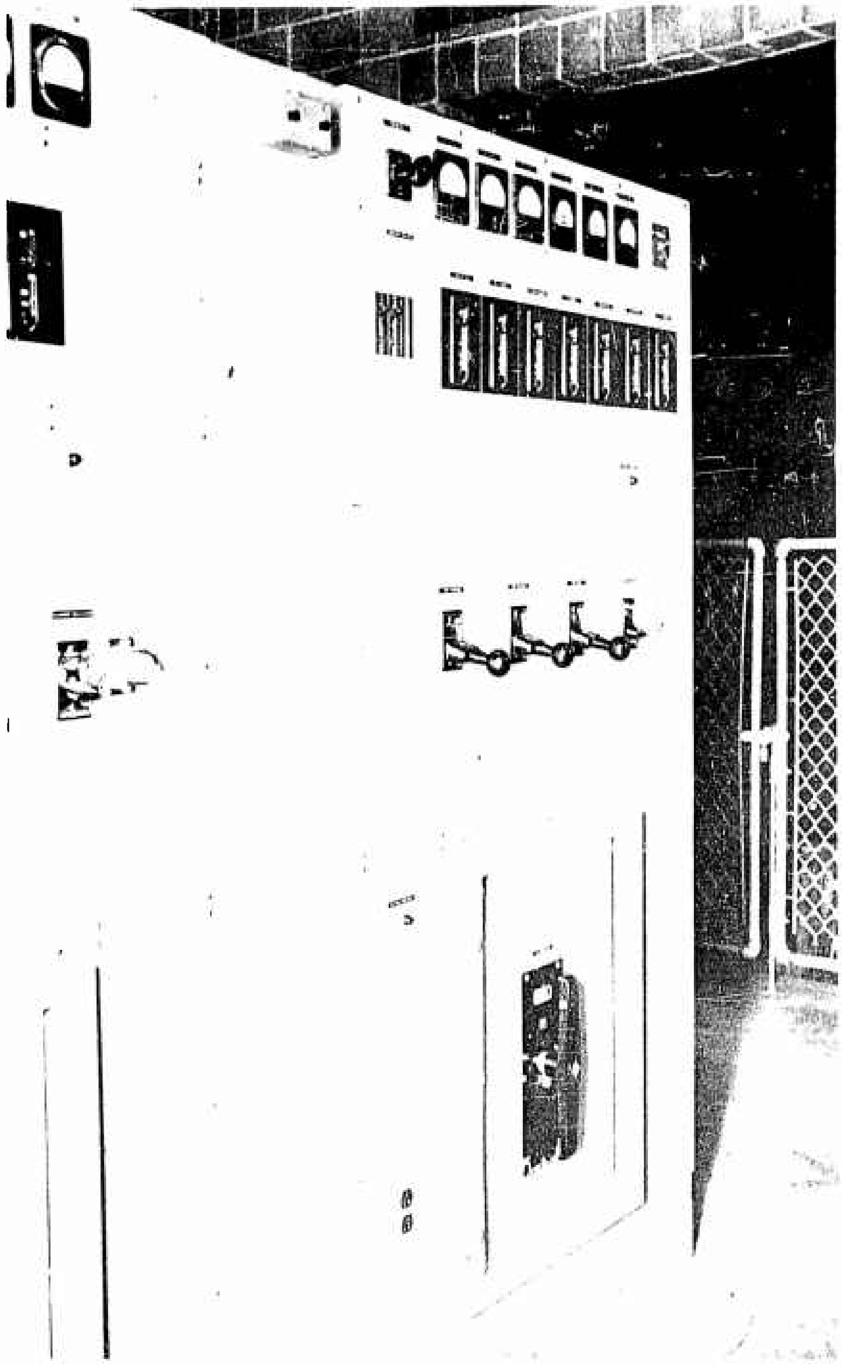


Fig. 2

in connection with changing the tube, which is especially complicated by the fact that water connections must be brought to the lower and upper end of the tube.

The entire plate circuit, or output circuit, has been constructed on an elevating shelf which is raised by four lead screws driven by an electric motor in the rear compartment (Figure 7). Before this motor can be energized it is necessary to remove two water connections, which supply the anode, and to withdraw two coaxial output connections in the rear compartment. These operations are mechanically linked to interlock switches which permit elevating the shelf by means of the motor and which also prevent operation of the water pump when the rear connections are open. With the shelf in the raised position, it is possible to disconnect two telescoping water tubes from the anode.

With the anode water connections removed, the entire input circuit structure may be withdrawn from the cabinet on ball bearing slides. (Figure 8) With the tube in this position,

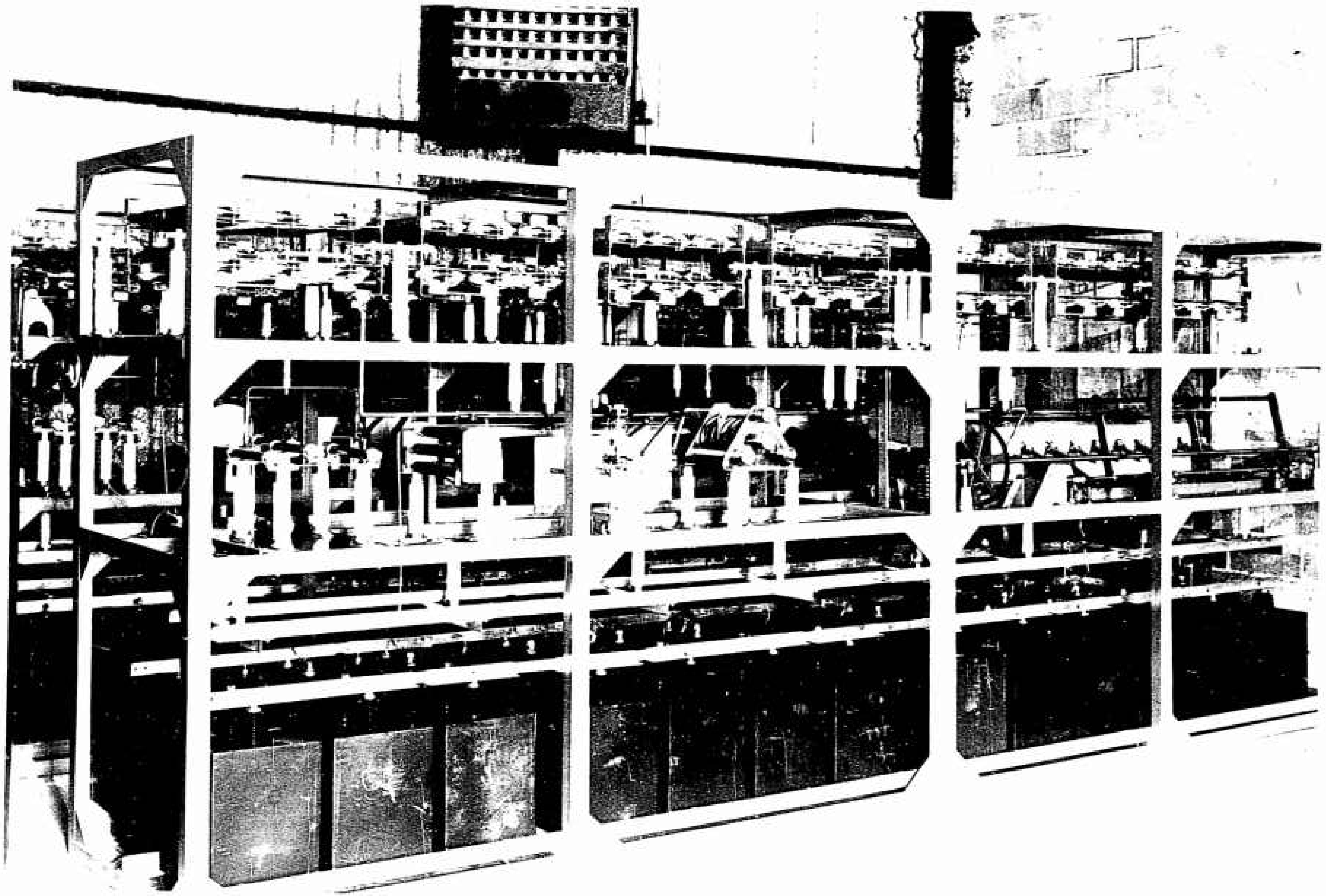


Fig. 3

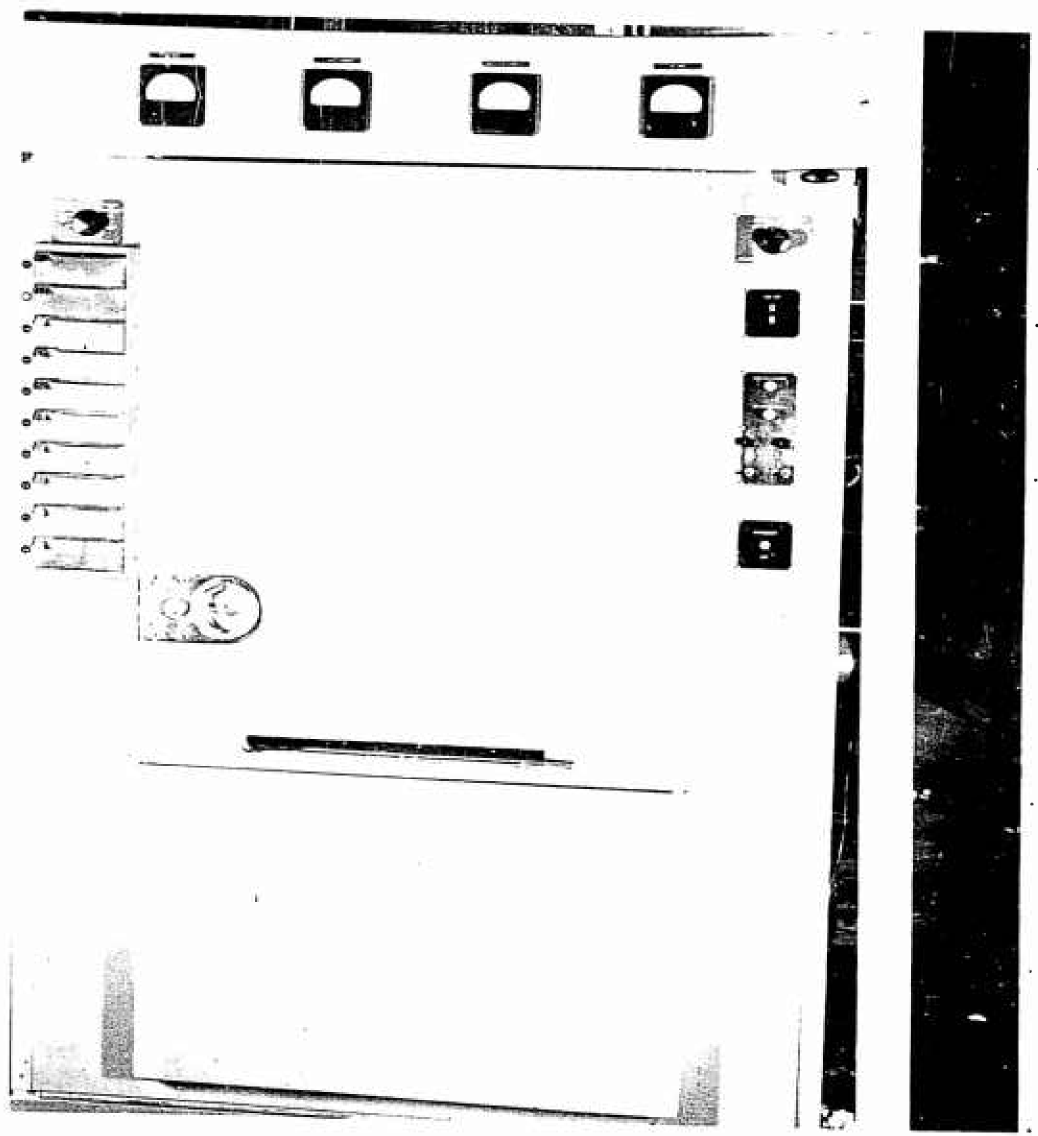


Fig. 4

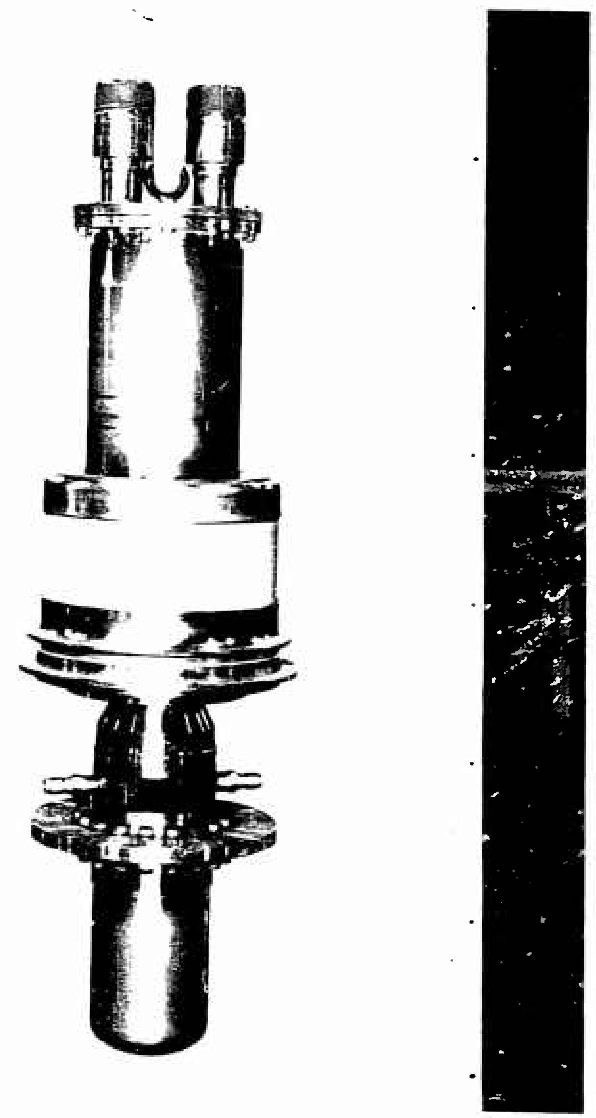


Fig. 5

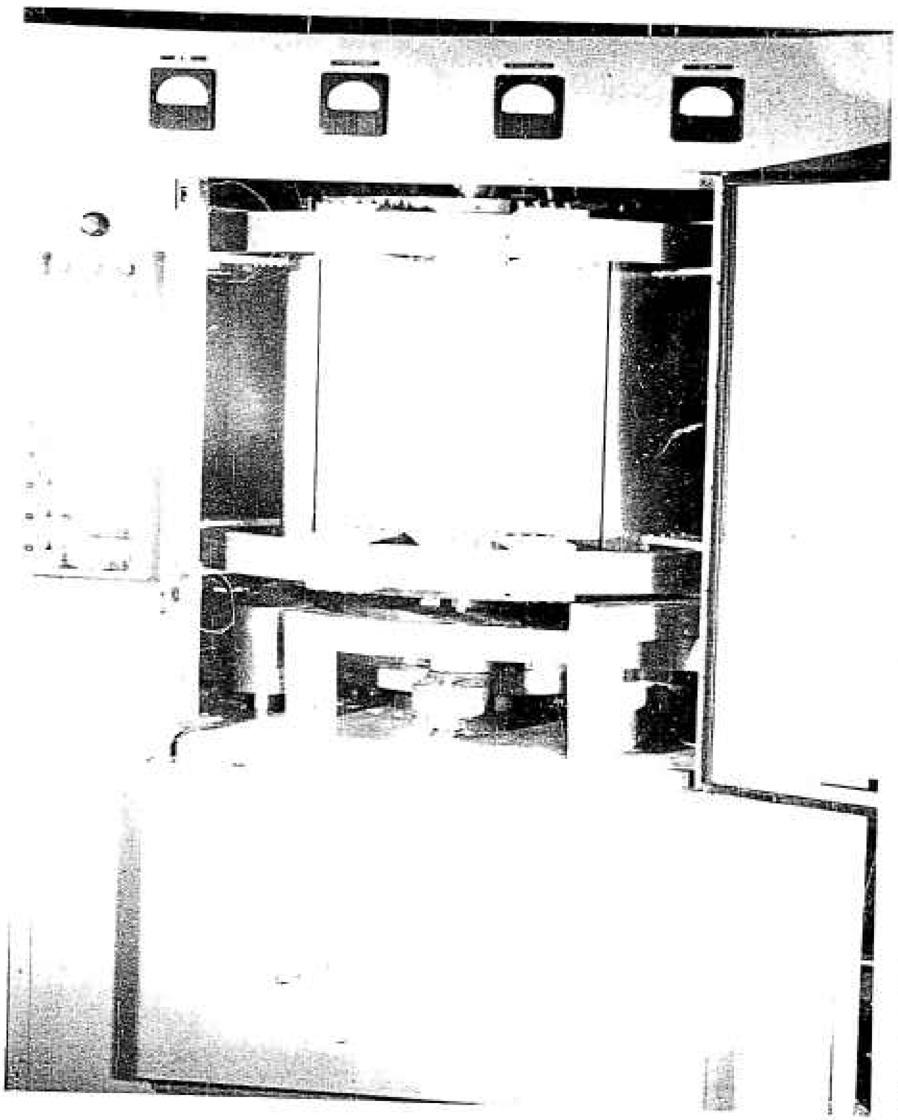


Fig. 6

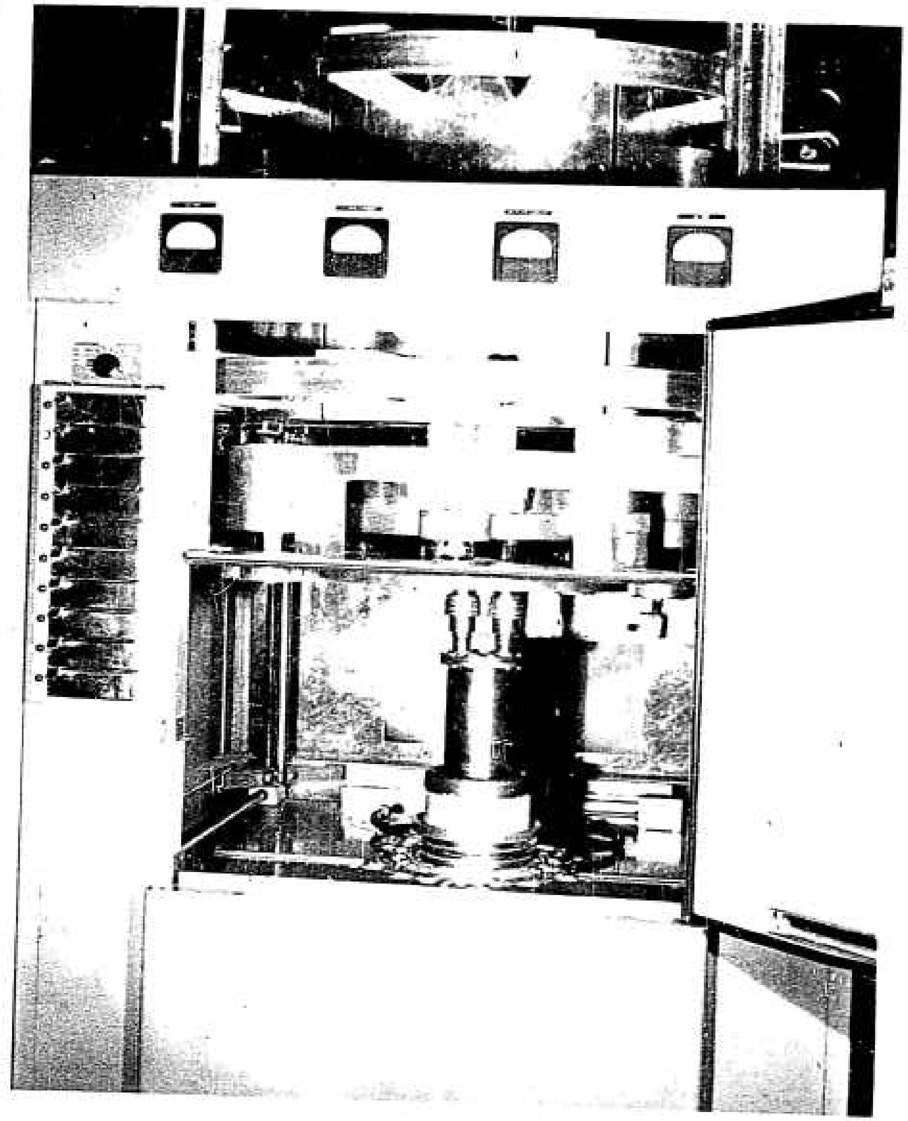


Fig. 7

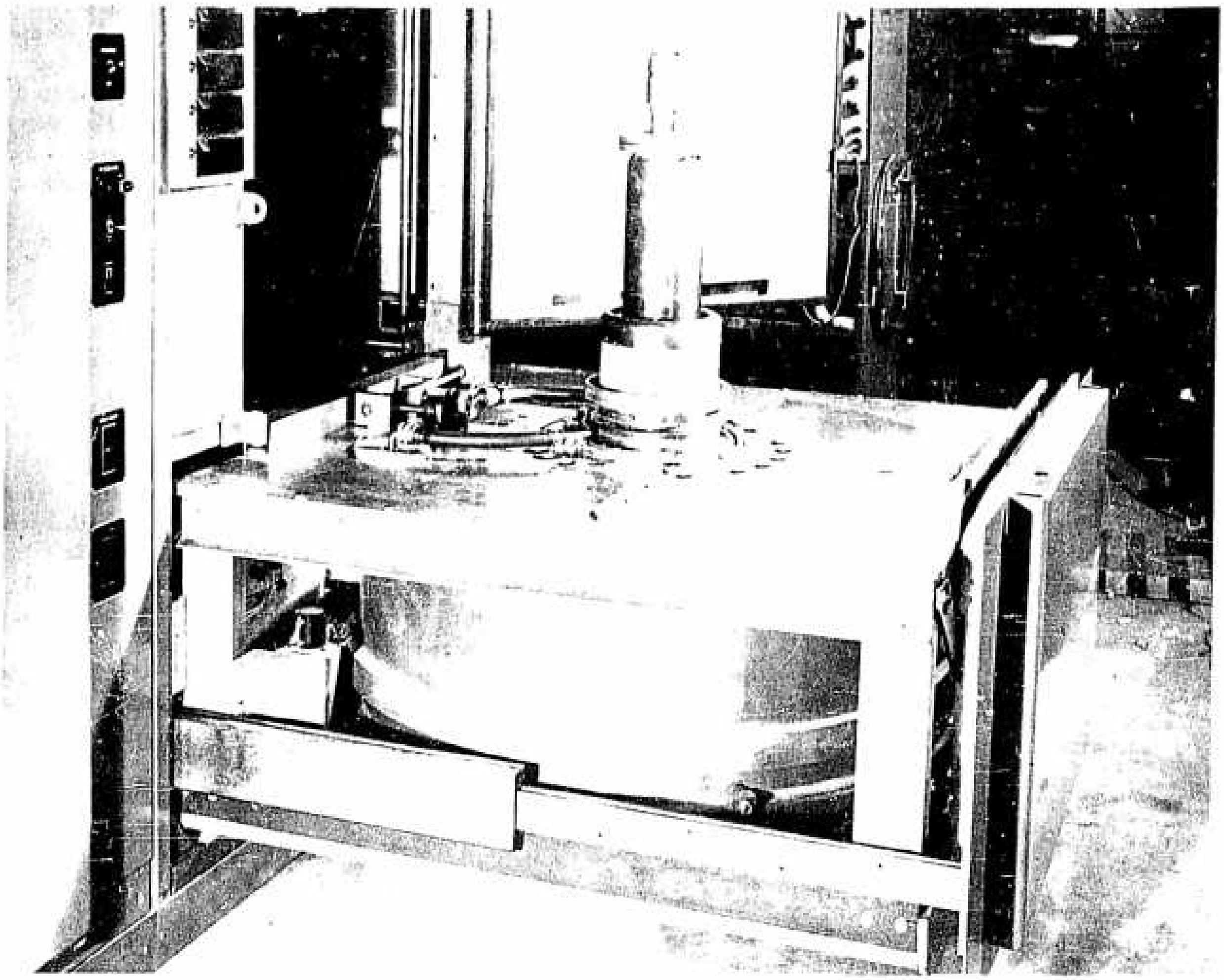


Fig. 8

clamping rings at the cathode return circuit and at the grid ring may be loosened, and the tube, which weighs 150 pounds, lifted out on a block and tackle. (Figure 9)

The grid or input circuit can best be described by reference to a cross-section drawing of the sliding drawer. (Figure 10) The circuit is shown schematically in the upper portion of this drawing. Because of the requirement for linearity, the excitation voltage is fed to a load resistor, or swamping resistor which is water cooled. This voltage is impressed across the input capacitor of the tuned circuit consisting of C1, L1 and C2. With this circuit in resonance, the ratio of the voltage at the input to the voltage at the grid will be equal to the capacity ratio, C1 over C2. A step-up ratio is used so that voltage at the grid is about 60% higher than the input voltage across the load resistor. Over the range from 8 to 30 megacycles, C2 consists only of the input capacity of the tube, and C1 is maintained at a constant capacity, the tuning over this range being accomplished entirely by inductance variation. As the tuning progresses downward from 8 to 4 megacycles, some capacity is added across the grid of the tube and the capacity of C1 is augmented.

Referring to the cross-section view, it will be seen that a connecting strap is attached at each side of the grid ring of the tube. These straps lead outward in opposite directions and connect to 1-1/2 inch copper tubing conductors which coil downward for 1-1/2 turns each, being wound in an interlaced fashion around the central metal cylinder. These two coils form the two separate inductance paths shown in the schematic which are electrically in parallel. These conductors are supported rigidly on the metal cylinder by means of G7 insulation blocks. A sliding contact is provided for each of the two interlaced conductors, the contacts being mounted on opposite sides of a cast rotating contact ring. This contact ring is held in place on vertical slide bars mounted on a large rotating cylinder and the weight of the contact ring is supported by 4 insulated rollers which rest on the heavy conductors of

the coil. The drum to which this contact ring is attached rides on a ball bearing approximately 4 feet in diameter and is equipped with a large ring gear at its lower edge so that this cylinder may be motor-driven by the tuning control motor. As the cylinder is rotated, the contact ring turns with it, sliding the contacts along the coil conductor while at the same time the rollers being supported by the coil conductor lower the contact ring downward in the cylinder or raise it upward with opposite rotation in tuning toward higher frequencies.

Outside the rotating cylinder there is located a grounded stationary cylinder with approximately 1/4 inch spacing between the two. These two large cylinders form the input capacitor C1. The rotating cylinder travels 1-1/2 turns from the lower end of the coil to a point where the contacts are at the top of the coil and only a fraction of an inch away from the large straps extending out from the grid ring.

The upper position is the tuning position for 30 megacycles. Underneath the contact ring there are a series of short concentric cylinders which form the upper plates of the padding capacitor in parallel with the input capacitor C1. When the cylinder is rotated in a direction to move the contact ring downward on the coil for about 3/4 of a turn, the tuning position for 8 megacycles is reached. At this point the short concentric cylinders under the contact ring begin to mesh with another series of concentric cylinders mounted on the base plate of the assembly. From this point to the lowest position of the contact ring, these cylinders become fully meshed adding additional capacity in parallel with the input capacitor C1.

Not shown in this drawing are two variable vacuum capacitors connected in parallel from the grid ring of the tube to ground. The drive for these capacitors is taken from the same motor which drives the tuning cylinder and so arranged that in tuning from 4 megacycles up to 8 megacycles, the vacuum capacitor plates arrive at the full open, or unmeshed position. From this point on as the circuit is tuned

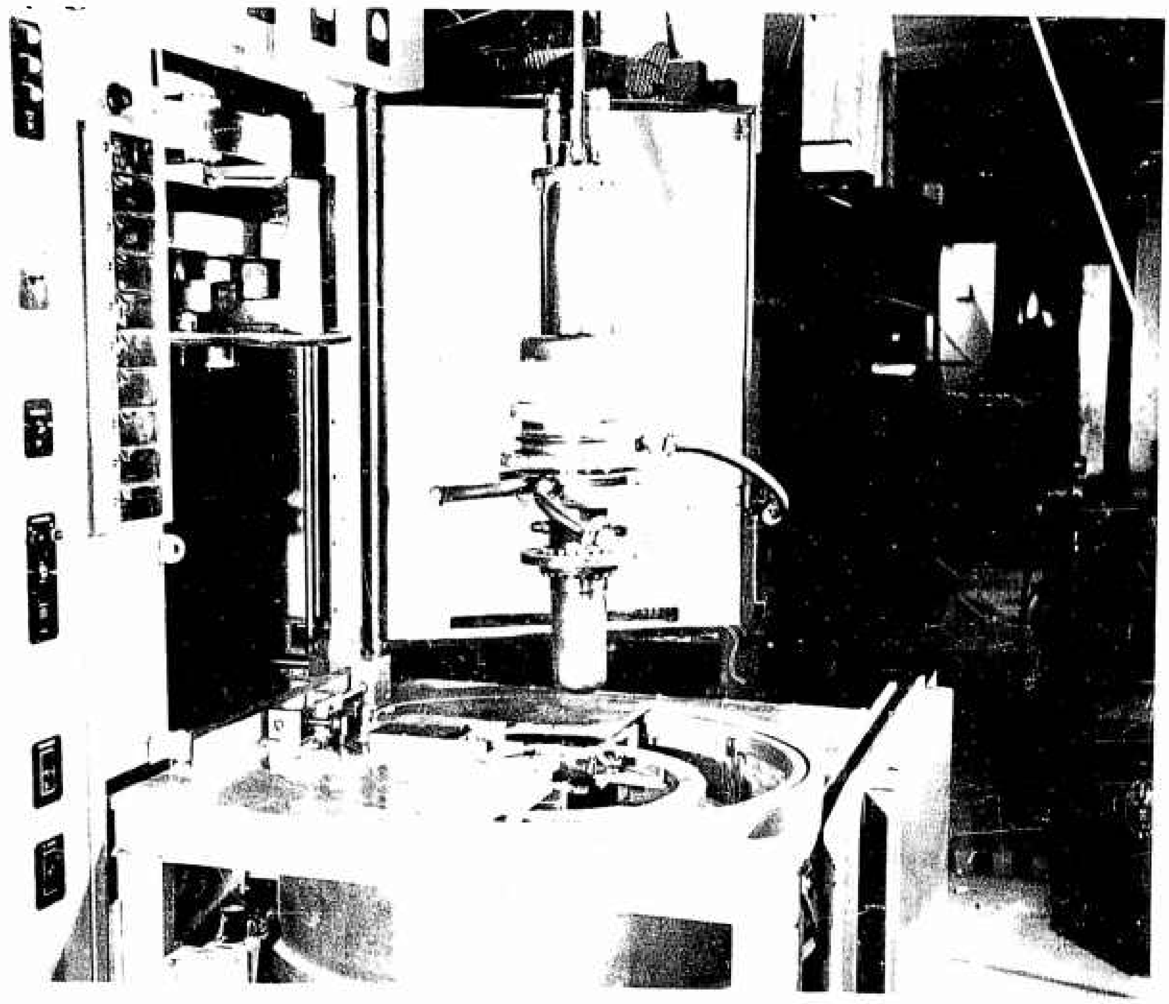


Fig. 9

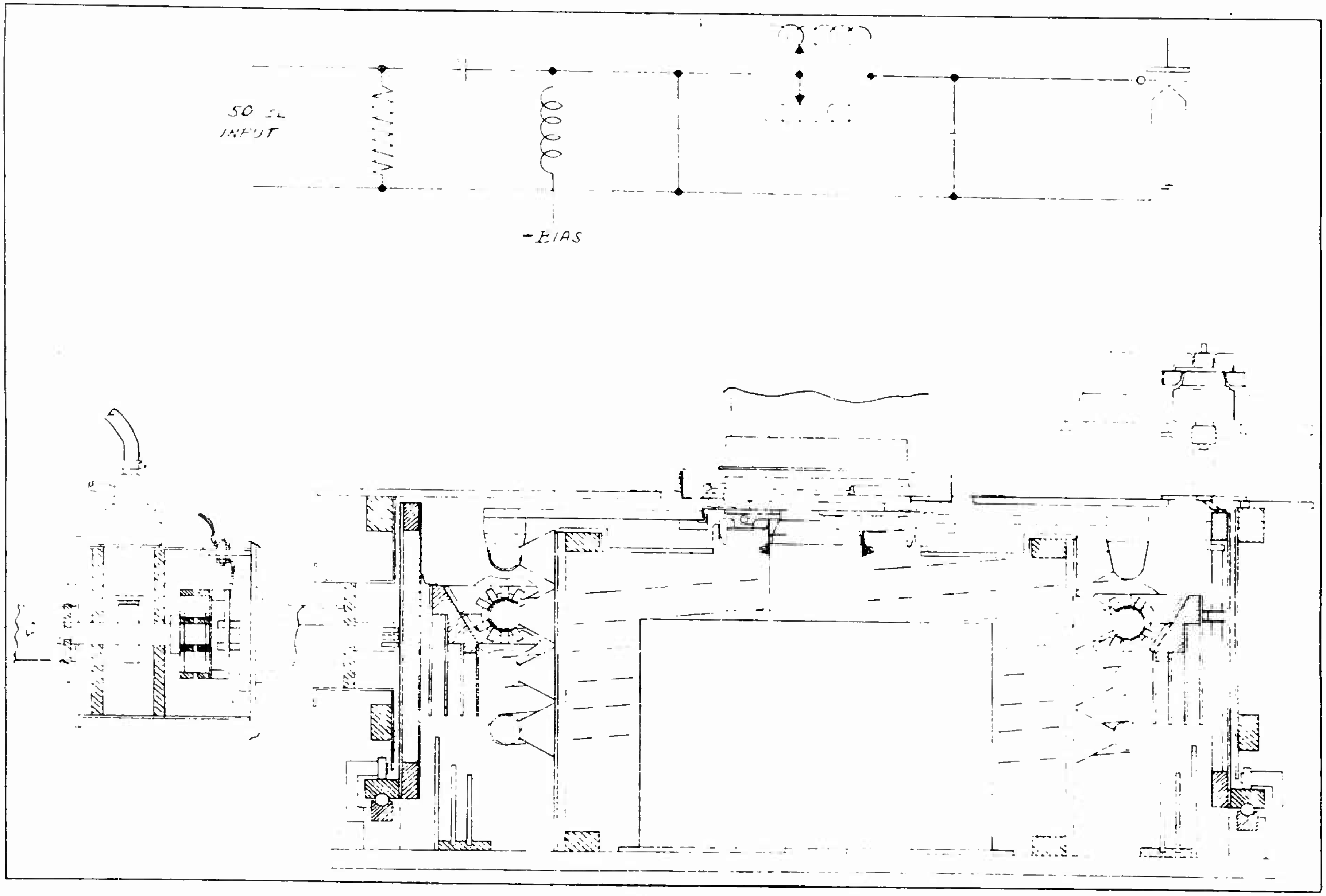


Fig. 10

toward 30 megacycles, the moving plates of the vacuum capacitors are caused to move farther away from the stationary plates but with practically no change in capacity since the plates are totally unmeshed. The action of these vacuum capacitors in increasing the capacity from grid to ground at the tube is thereby kept in step with the large cylindrical padding for the input capacity C1, maintaining the voltage step-up ratio from input to grid substantially constant over the entire tuning range.

Sliding contacts on the inside of the rotating cylinder maintain contact between it and the cast contact ring as the ring travels up and down with rotation of the cylinder. The input radio frequency voltage and bias voltage is brought to a contact located at the rear of the sliding drawer. This contact slides on the outside of the rotating cylinder which is the feed point for the network. Bias voltage is brought to this input line through a radio frequency choke and a capacitor blocks the bias off of the swamping resistor and the input line.

It will be noted that the conductors of the input inductance are wound in close proximity to the center of the metal cylinder and also that these conductors are surrounded at a close distance by the outer rotating cylinder. The inductance therefore has been designed from transmission line formulae rather than as an inductance coil. This has the advantage of permitting greater conductor length for a given inductance value than would be the case for an inductance coil configuration. This construction together with the wide straps extending from the grid ring closely spaced between ground plates above and below them permits the circuit to reach 30 megacycles and at the same time have a tuning range extending to 4 megacycles with the simple tuning variation accomplished by 1-1/2 turns of the rotating cylinder.

There is some advantage gained by having the radio frequency return circuit connect to the cathode at points both below and above the grid ring. This takes advantage of the internal construction of the tube bringing out cathode return circuits at these two points and is of some assistance in reducing the inductance of the connecting leads.

With the input circuit in resonance, there is a 180 degree phase difference between the voltage at the grid and the voltage across the input capacitor C1. This phase difference may be utilized in connection with neutralization. As shown in the drawing, one side of the neutralizing capacitor is connected by a sliding contact to the upper edge of the rotating cylinder of C1. The other side of this neutralizing capacitor is connected to the plate of the tube through the plate blocking capacitor. Because of the low inter-electrode capacity between plate and grid (13 micromicrofarads) neutralization is not particularly critical at 4 megacycles. It has been found possible to adjust the neutralizing capacitor for proper neutralization at 30 megacycles and operate through the entire frequency range without readjustment.

This drawing also shows the filament transformer which is located at the center of the sliding drawer inside the small drum which supports the inductor.

The filament transformer (Figure 11) is of special design with contact fingers which contact the filament rings of the tube directly.

This transformer also serves as the tube support.

Figure 12 is a view looking down into the input circuit assembly with the top cover plate removed.

Output Circuit

Schematically, the output, or plate, circuit is similar to that used at the input. (Figure 13) The capacitor C1 consists of 5 variable vacuum capacitors, each having a maximum capacity of 450 micromicrofarads, providing a total capacity range of approximately 100 to 2200 micromicrofarads.

The capacitor C2 consists of 8 variable vacuum capacitors, each having a maximum capacity of 800 micromicrofarads. The inductor is variable over an inductance range of approximately 8 to 1. (Figure 14).

A single motor controls the inductor and the capacitor C1 for adjusting the output circuit to resonance. Another motor controls the capacitor C2 and is used as a load impedance adjustment. The transformation ratio of this circuit provides an impedance transformation from 180 ohms plate to ground at the tube to 25 ohms which is the input impedance of the matching network in another cabinet. A cylindrical blocking capacitor of special design fits inside of the tank inductor and over the anode of the tube.

The inductor design is unique and may be described from the schematic shown in Figure 15. Physically, it has the external appearance

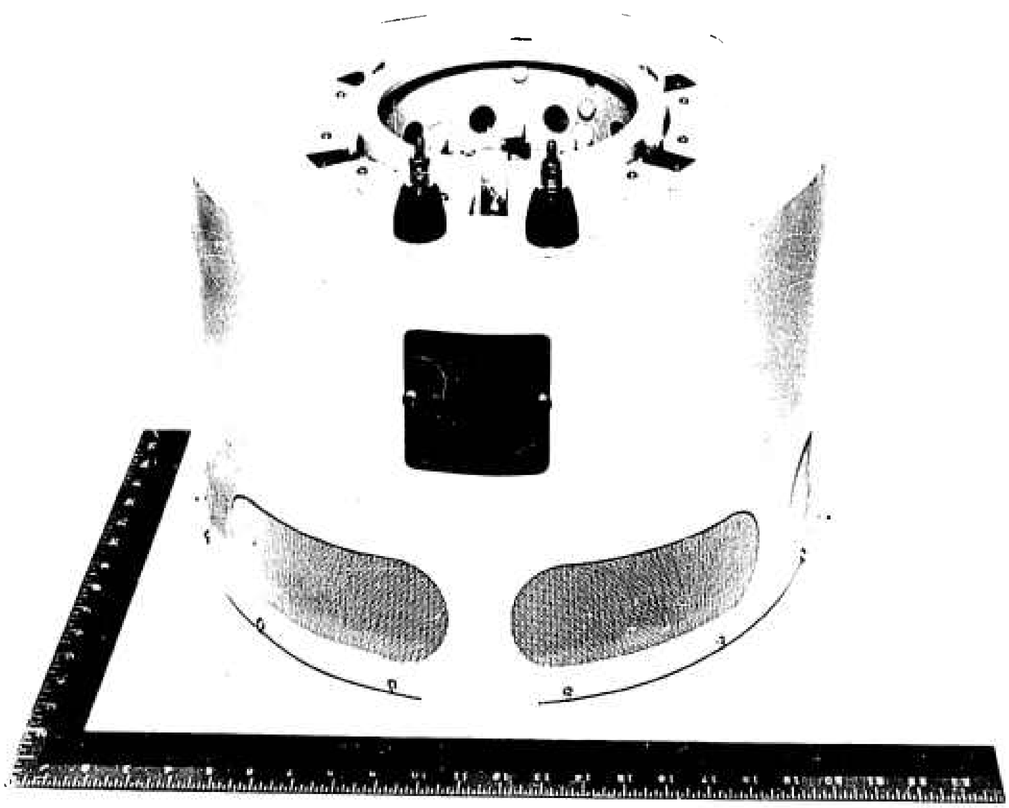


Fig. 11

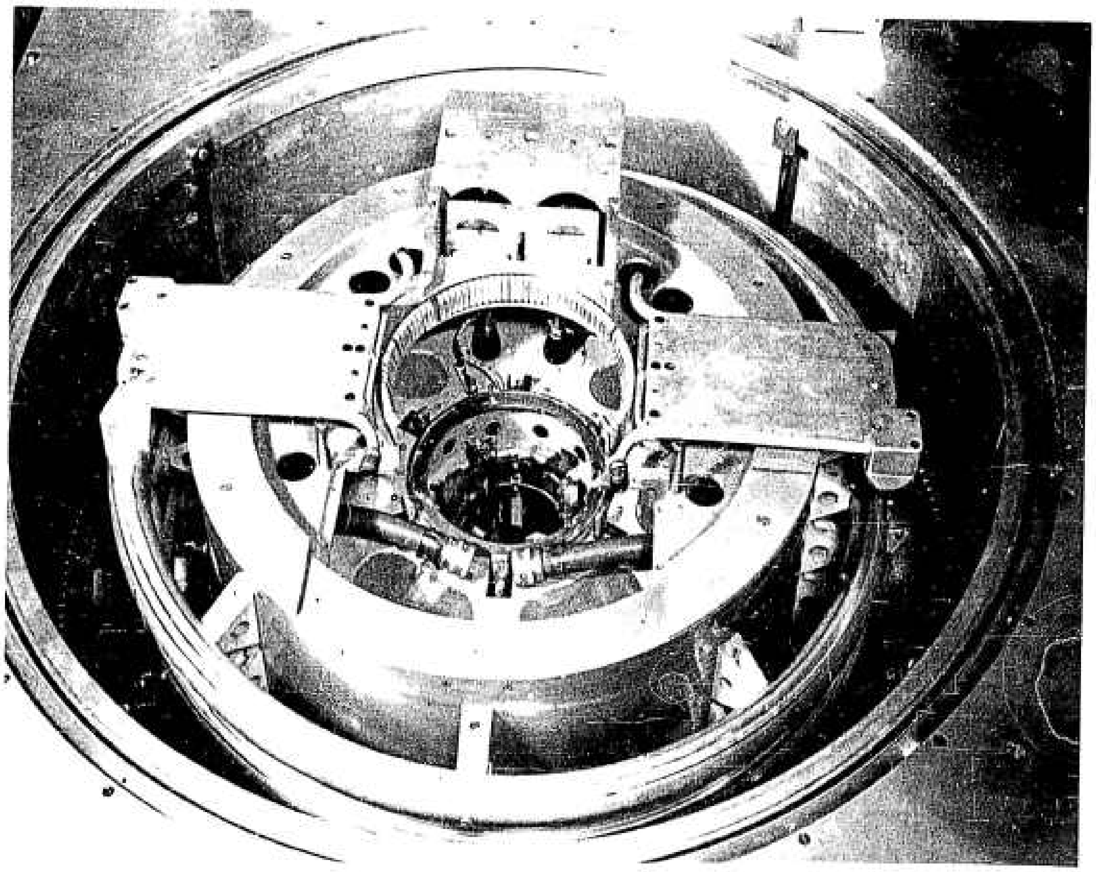


Fig. 12

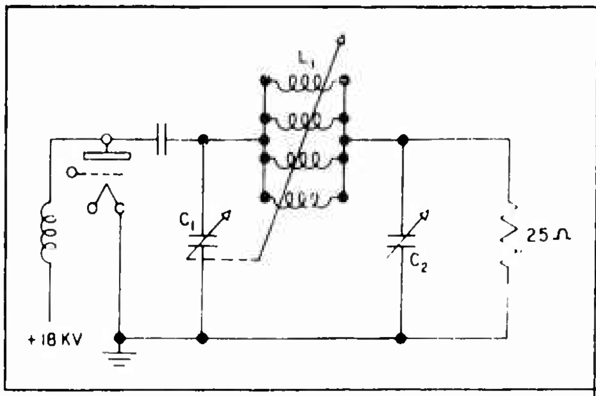


Fig. 13 - 600 kw amplifier output circuit.

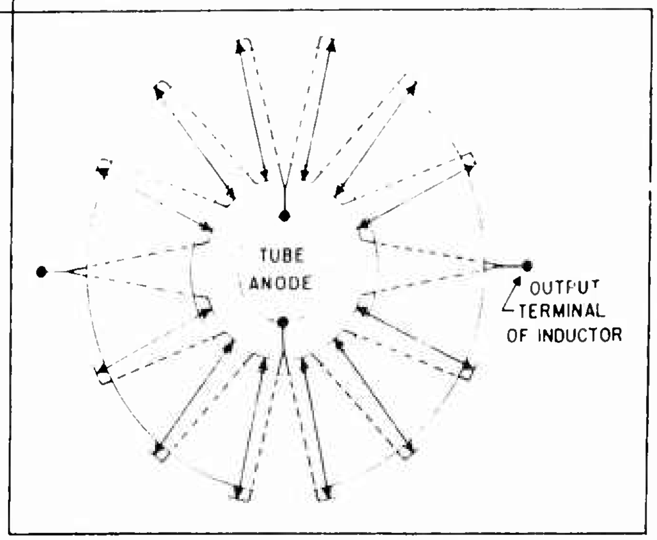


Fig. 14 - Schematic representation toroidal inductor 600 kw hf P.A.

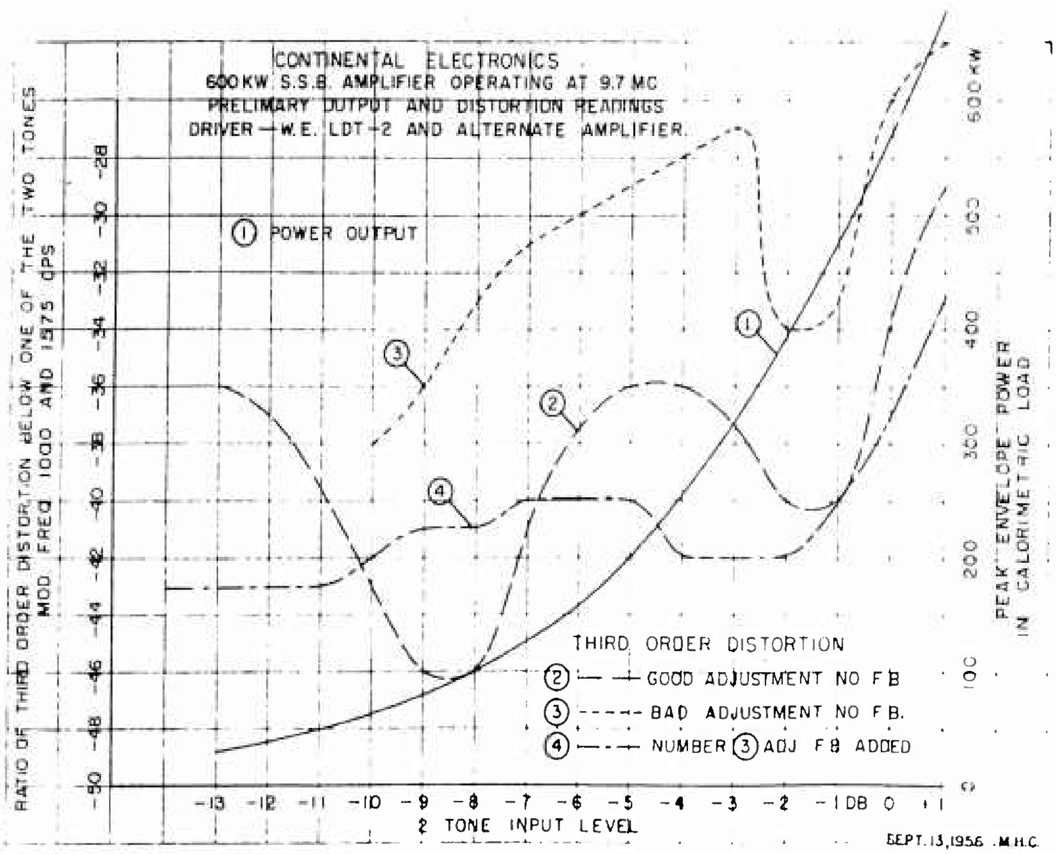


Fig. 15

of a short section of very large coaxial transmission line, having an outer conductor of about 40 inches diameter and an inner conductor of about 14 inches diameter with a total length of about 30 inches, with both ends sealed by a shorting disc from inner to outer conductor. Thus its outline has roughly a doughnut shape, but it is actually formed as a toroidal winding using flat copper conductors which conform to the shape described. Schematically, the inductor has two inner terminals and two outside terminals and consists of four winding sections, each of which must carry about 104 amperes of circulating current for a total tank current of 416 amperes. By following the schematic diagram, it will be noted that from a terminal connected to the plate of the tube, the winding proceeds around the toroidal section in opposite directions to points 90 degrees away from the anode connection point. Two other similar windings proceed from the anode connection point at the opposite side of the tube, arriving 90 degrees away in each direction at the outer terminals of the other windings. It will thus be seen that internally the toroid is made up of four sections of winding aiding since current flows upward on the inner cylinder and downward on the outer cylinder of all turns. However, externally, the winding progresses in opposite directions in each alternate quarter section of the toroid. The result is that the external field of such an inductor cancels, providing a considerable advantage in the reduction of shielding losses.

The supporting rings for this toroid which are insulated from it by G7 support blocks are only spaced approximately 4 inches away from the inductor and totally surround it. Because of the absence of external field, these shorted turns around the inductor have no appreciable effect on its inductance. In order to vary the inductance for tuning a shorting disc is moved up and down on the inside of the inductor, this disc being made up of 12 wedge shaped segments, which short each turn individually, there being three turns in each quarter section of the inductor. Special alloy contacts with spring pressure arrangements are used and the multiple contacts provided result in a current per contact to 10 amperes. An insulating disc carrying the 12-turn shorting segments is moved up and down within the coil by means of three brass lead screws which are motor driven. One lead screw extends through the lower side of the toroid and connects with the drive mechanism for the five plate tuning capacitors below the inductor.

In order to have the shorting disc segments moved vertically up and down on the lead screws, it is necessary that the toroid turns be vertical on the inner and outer cylinder and symmetrically connected together at the top of the toroid. Therefore, the transition from turn to turn is made entirely on the bottom side of the inductor.

Performance

A typical intermodulation distortion curve showing the performance capability of the amplifier under single sideband suppressed carrier operation is shown in the Figure. In making the measurement, the amplifier was driven by a single tube amplifier also developed in connection with the same work having a peak envelope output power capability of approximately 30 kilowatts. This driver amplifier was in turn driven by a Western Electric Type LDT-2 4 kilowatt peak envelope power, single sideband transmitter. It will be noted that the third order intermodulation product is at least 35 db below single tone level for any power output up to 600 kilowatts peak envelope. The plate efficiency at 300 kilowatts average power output was approximately 50%.

An inverse feedback circuit developed for use on amplifiers in single sideband service was in operation when these measurements were taken.

Distortion curves, of operation with and without inverse feedback on the high power stage are shown here.

FACTUAL DATA

1. FACTUAL DATA

1.1 Scope.

The work accomplished on a task by task basis, as outlined in the Purpose section of this report, is covered with emphasis given to those areas of unusual difficulty.

1.2 Group One - Modification of Radio Transmitting Set AN/FRT-22.

(a) Nomenclature. The nomenclature of the "Modified AN/FRT-22" includes:

(1) Radio Transmitter T-454/FRT-26 (modified)

(2) 40-Kw Amplifier

(3) Power Supply Assembly PP-1088/FRT-26 (modified)

(4) 10-Kv Power Supply

(5) Power Supply PP-454/FRT-5

(6) 5-Kv Power Control

(7) 10-Kv Power Control

(8) Power Transformer TF-196/FRT-26

(9) 10-Kv Power Transformer

(10) R-F Oscillator 0-91/FRT-5

(11) R-F Oscillator 0-270/FRT-26

(12) Frequency-Shift Keyer KY-45/FRT-5

(b) Modification. Cold measurement analysis of the AN/FRT-26 amplifier was performed to gain knowledge for the necessary changes in physical construction for alteration of its frequency range. The first and second multiplier plate circuits were modified to cover 30.3 mc, and a revision of the tuning range of the driver stage was made for temporary operation to 30.3 mc.

At this point a balanced dissipative load capable of 15-kw dissipation over the 20 to 30.3 mc range was connected to the output of the AN/FRT-26 equipment. This allowed a study, in a prototype model, of the upper frequency range changes. When the driver portion of this amplifier was operated into the dissipative load, the tuning was found to be too sharp on the high end of the tuning range.

To study the effects of the modifications for other frequency range coverage, a Corning glass resistor load for operation over the frequency range of 4 to 65 mc with a rating of 20-kw average power was designed and installed. The equipment was then operated over the entire range of 4 to 30 mc at the rated power output and the tuning characteristics of the circuits of the high end of the band were broadened.

The protective functions of the AN/FRT-26 and the 40-kw alternate amplifier were integrated with those of the 300-kw hf amplifier group through the power-control-interchange panel. Interlocking of the automatic re-start circuits of the modified AN/FRT-22 with those of the 300-kw equipment was also carried through the power control-interchange panel.

1.3 <u>Group Two - The 300-Kw HF Amplifier Group</u>.

(a) Unit Identification. The following table lists all of the major units of the 300-Kw Amplifier Group, together with the common names by which they are known. It shows the locations of all units, including minor units which are contained within the cabinets of the major units, and lists the symbol number groups assigned to the units. The unit numbers shown

in the third column represent the hundred series of symbol numbers assigned to the units, e.g., the symbol number series assigned to Unit 5 includes all numbers from 501 through 599.

NAME PLATE	COMMON NAMES	UNIT NO.	LOCATION
RF Amplifier	PA, Power Amplifier, Power Amplifier Unit, RF Amplifier Unit	5	Second cabinet from extreme right of main cabinet group.
	Feedback Amplifier Z501	35	Upper right rear section of RF Amplifier Unit cabinet.
	Servo Control Panel Z502	36	Left front panel of RF Amplifier Unit cabinet.
	Voltmeter Probe Plate-Z504 Grid-Z503	40	Plate-Center rear portion of plate shelf. Grid-Lower center part of the rear section of the RF Amplifier Unit cabinet.
	Load Control Probe Z505	39	Center rear portion of plate shelf.
Servo Power Supply	Balanced Rectifier Servo Power Supply Z506	43	The servo amplifier and the servo power supply are contained in one unit which plugs into the upper rear section of the right side of the RF Amplifier Unit cabinet.
Servo Amplifier	Balanced Rectifier Servo Amplifier Z507	44	
	Servo Positioner Z508	45	Upper right rear section of the RF Amplifier Unit cabinet.
	Feedback Amplifier Pick-up Probe-Plate Z509	54	Rear portion of plate assembly of RF Amplifier cabinet.

NAME PLATE	COMMON NAMES	UNIT NO.	LOCATION
	Feedback Amplifier Pick-up Probe-Grid Z510	55	Lower center part of the rear section of the RF Amplifier Unit cabinet.
Output Network	Output Network Unit	6	First cabinet at extreme right of main cabinet group.
	Servo Control Panel Z601	37	Left front panel of Output Network Unit.
	Pi Capacitor Servo Amplifier Z607	34	Lower right front section of Output Network Unit cabinet.
	ARC & SWR Protective Device Z605	46	Center left front section of Output Network Unit Cabinet.
	ARC & SWR Protective Device Power Supply Z606	48	Center right rear section of Output Network Unit cabinet.
	Pi Capacitor Servo Control Panel Z603	50	Right front panel of Output Network Unit.
Control	Control Unit	26	Third cabinet from extreme right of main cabinet group.
Servo Amplifier-Grid Tuning Z2601	Grid Tuning Servo Amplifier	34	Center front section of Control Unit cabinet.
Servo Amplifier Plate Tuning Z2602	Plate Tuning Servo Amplifier	34	Center front section of Control Unit cabinet.
Servo Amplifier-Plate Loading Z2603	Plate Loading Servo Amplifier	34	Center front section of Control Unit cabinet
Servo Amplifier-Output Ind Z2604	Output Network Inductor Servo Amplifier	34	Center front section of Control Unit cabinet.
Servo Amplifier Output Cap Z2605	Output Network Capacitor Servo Amplifier	34	Center front section of Control Unit cabinet.

NAME PLATE	COMMON NAMES	UNIT NO.	LOCATION
Rectifier No. 1	Rectifier Unit No. 1	25	Second cabinet from extreme left of main cabinet group.
Rectifier No. 2	Rectifier Unit No. 2	24	First cabinet at extreme left of main cabinet group.
Distribution	Distribution Unit, Switchgear	31	In Power Vault.
Dummy Load	Dummy Load, Phantom Antenna	47	In Power Vault.
Balun	Balun, 300-Kw Balun	42	Outside between transmitter building and antenna, strung from poles on strain insulators.
	Power Vault	27	Fenced off portion of the transmitter room which contains the high voltage transformers, filter choke and filter capacitor rack. The Distribution Unit, Plate and Filament Regulators and the Dummy Load are also fenced in by the Power Vault.
	Pump Room, Cooling Equipment	28	Room of transmitter building containing the 300-kw cooling equipment and the Dummy Load cooling equipment.
	External Rf Equipment	23	Consists of the ANTENNA TRANSFER Switch which is mounted on the Dummy Load cabinet, the overhead mounted coaxial transmission line switches and the RF SWITCH POSITION indicator panel which is mounted on the wall to the rear of the 40-kw Amplifier Group.

(b) The Output Network.

(1) General. The 300-kw output network was originally conceived to be a balanced 600-ohm output with a nominal 2 to 1 vswr capability. The input to this output network at that time was 150 ohms single-ended with tuned elements to give a 600-ohm balanced output with a capability of 2 to 1 vswr.

With the electrical design completed, mechanical design of the tuned balun was started. Parts were released to the shop for manufacture as the design progressed to the point of fabrication.

(2) The Tuned Balun. The circuit for the tuned balun was basically a parallel resonated tank with balanced series "L" matching sections.

(3) Transmission Line Investigation. While a 600-ohm transmission line performs very satisfactorily for low power operation where voltage between lines does not reach the point of corona, an impractical duct size of 44 inches by 22 inches with two No. 6 wires, 22 inches apart, would be required to maintain a 600-ohm line that would handle the 300-kw average power and 600-kw peak power. It was at this point of the development that a 300-ohm line impedance was suggested for the inside-the-building balanced transmission lines and an external 300- to 600-ohm tapered line for field application. This decision necessitated the design of an output network with a 75-ohm single-ended input to a 300-ohm balanced output which was capable of 2 to 1 vswr operation.

As mentioned above, the input impedance to the tuned output network was 150-ohms. This 150-ohm impedance had now become 25-

ohms for reasons discussed in another section of this report. Therefore, the configuration required became a 25- to 75-ohm "L" matching single-ended network with the requirement of a 75- to 300-ohm balun device capable of the 2 to 1 vswr.

(4) The Untuned Balun. An untuned balun was investigated because of the complicated tuning procedure of a tuned balun. This would eliminate three tuning controls, even though the first investigation indicated that two untuned baluns, that could be switched in and out might be required to cover the frequency range.

As progress was made in the area of an untuned balun that would operate at this power level and frequency range, the desirability of a 50-ohm single-ended output configuration of the "L" matching section became the criterion.

(5) "L" Matching Section. The "L" matching network thus transforms from 25-ohms plus j0 to 50-ohms plus j0 with a specific requirement of 2 to 1 vswr. Two tuning controls were required during the original development work, one for theoutput shunt capacitor and one for the series inductor of the "L" matching network.

While every precaution was taken to construct the series inductor in the form of a transmission line, as all the inductance is shorted out, the minimum inductance would not allow a 25-ohm to 25-ohm transformation at the high frequency end of the band. Similarly, the total capacity in shunt with the transmission line, when operating into a 25-ohm characteristic to allow a perfect match at the low end of the frequency spectrum, was not large enough.

During operation of the "L" matching network (as originally installed to match the output of the 300-kw amplifier to a 50-ohm dummy load) the main contacts of the inductor failed. evaluations and a series of redesigns of the contacts were made and a blower was added to the unit to provide adequate cooling of these contacts during continuous operation.

The inductor was water cooled.

(6) Metering. Throughout the period of the development of this equipment, various suppliers were solicited to provide the best of metering capabilities for control of the tuning required by the "L" matching network. One of these, M.C. Jones, Micro-match division, reported that the 4 to 30 mc frequency range, as well as the power output of 300-kw average and 600-kw peak, put the requirements of our particular vswr indicator outside of the capabilities of the company at that time.

Continental Electronics engineers successfully designed and manufactured vswr indicators for application in the 300-kw section of this amplifier. Throughout the rf testing of the output network, preventive steps were taken from time to time to shield the stray rf from the metering circuits.

(7) Protective Device. In high power amplifiers, working at high gradient voltage conditions, it is not uncommon to find what is referred to as an "arc protective unit." If an arc is caused in the rf circuitry for any reason, the rf energy from the amplifier will normally sustain this arc; therefore, it is essential that the rf excitation be squelched to prevent damage.

An arc and vswr protective device was incorporated into the equipment for these reasons. The evolution of this protective

device started with the use of the power amplifier bias supply as a source of energy. This system could never be made fast enough to provide adequate protection from damage due to the rf energy.

A separate, negative 1800-volt dc power supply was designed and a complex choking arrangement was incorporated to apply the voltage to the elements of the transmitter and the transmission line. The complications encountered with the rf choking arrangement were hot spots on the chokes at the high end of the band and insufficient choking at the low end of the band. Resistive loading of the chokes solved the problem.

(8) Mechanical Arrangement. The output network was constructed in a cabinet approximately 44 inches wide, 59 inches deep, and 78 inches high. The electrical length of the 25-ohm transmission line required to couple to the input of the "L" network was approximately 15 inches, but as originally positioned and connected to the power amplifier, there was an additional length of 25-ohm transmission line of about 10 or 12 feet.

While determining the capabilities of the 300-kw transmitting equipment as a system, conditions indicated that the long length of transmission line between the output section of the power amplifier plate "pi" circuit and the input of the "L" matching network caused difficulties in the harmonic content of the transmitter output. The first step in determining the effect of this long length of transmission line between the power amplifier and the output network was to increase the length of the line and observe the effects on the harmonic output of the transmitter.

It was at this point that the data which had been collected indicated that the shortest possible length of transmission line

between the power amplifier unit and the output network would minimize the difficulties. For this reason, the water cooled output network cabinet (44 inches wide, 59 inches deep and 78 inches high) was positioned on its side to the rear of the power amplifier unit. The mechanics alone of this change required one week of work.

While the output network was mounted in this position, a new problem was discovered during the hours of data taking and testing of the unit. Basically, this problem was the effect of the transmission line length between the output section of the "pi" network and the input section of the "L" network transforming from the dummy load through the "L" matching network and the length of line to a plus reactance component that parallel resonates the output capacity of the plate "pi" network at the second harmonic. This occurred during operation of the transmitter on 21.5 mc. The 43 mc harmonic energy exceeded the fundamental.

This was a significant reason but not the only reason for the problems in this area. The input of the "L" matching network was shunted with a capacitor, referred to as the harmonic "pi" capacitor, in order to reduce the effects at the second harmonic of the impedance being reflected to the output section of the plate "pi" network. The problem of determining the tuning curve required for the harmonic "pi" capacitor and the problem of adding a servo control unit for this capacitor were solved.

The output network was installed in its original position but the mechanical configuration was completely reversed so that the shortest possible feed could be made between the output section of the "pi" network of the power amplifier unit to the "L" matching network.

(c) The Balun. Because of the circuit complexities and design problems associated with tuned baluns, a study of untuned baluns was started. Two types of baluns were considered. The first of these was a parallel wound transmission-line balun with the low-impedance-end having the transmission lines paralleled and the high-impedance-balanced-end having the transmission lines in series. The second study involved the loop balun.

A full scale model of the parallel wound transmission line balun was constructed and impedance and balance measurements were made. The data indicated that the balance-to-ground would not be satisfactory and that the full frequency range of 4 to 30 mc could not be covered with one balun. A system of switching two or more of these baluns would be required to completely cover the frequency range.

A study of the loop balun, as originally conceived by a group of German engineers, was undertaken. A translation of the German article became the forerunner of the work toward a loop balun for this power and frequency range.

Under a separate contract to the Signal Corps, the Developmental Engineering Corporation in Washington, D.C., had been awarded a contract for a design study of the loop balun for high power transmitters and high power transmission lines. The prototype work that this company did on high power baluns produced a balun supposedly designed for 300-kw average power, 600-kw peak power with the design objectives to be better than 1.2 to 1 over the frequency range of 4 to 30 mc. This loop balun was constructed with a square cross-section and an externally flat tapered exponential line. Reference to the data related to the

loop balun work completed by Developmental Engineering Corporation (prior to the time Continental Electronics manufactured a high power loop balun) is included in the publications section of this final technical report.

To ensure mechanical stability and yet remain light weight, six inch aluminum conduit was chosen as a main conductor for the prototype model of the high power loop balun constructed by Continental Electronics. The design objectives of this balun were for a single ended impedance of 50-ohms to be transformed to 300-ohms capable of withstanding the voltages and currents involved with a 2:1 vswr.

Early work on the prototype balun indicated that the 50-ohm to 300-ohm device was quite practicable, but the time element would not justify the efforts for creating this type of balun. As a compromise, the impedance of the loop balun became 50-ohms single-ended to 220-ohms balanced over the frequency range of 4 to 30 mc with the vswr not exceeding 1.4 to 1 throughout this range.

Power testing of the loop balun was accomplished by placing the balun on the roof of the transmitter test area. A 6-1/8 inch 50-ohm transmission line was connected to the balun by routing it through the roof over the output network. This line connected to the input side of the balun while the output side of the balun fed parallel 220-ohm transmission lines that tapered to a 200-ohm nominal impedance. The 200-ohm impedance was connected through 100-ohm single-ended lines to the dummy load. The dummy load was constructed in such a way that two 100-ohm resistors were paralleled to form a 50-ohm load which could be

operated as a 100-ohm load on each side, i.e., as a 200-ohm balanced load.

Only one frequency of operation was completed into the dummy load arrangement as described above. This frequency was approximately 8 mc. The only other frequency of power test for the loop balun was made at 21.570 mc. This frequency was used during one week of propagation test studies conducted for the Signal Corps during the development of the transmitter.

The remaining power tests of the loop balun were conducted at the installation site of the 300-kw hf transmitter at Woodbridge, Virginia. At that site, twenty-five frequencies were employed, tested and checked out, ten of which were applied to the antenna and loop balun. No adverse effects were noted throughout the power testing of the loop balun while conducted by engineers from Continental Electronics.

It was determined at a later date that a cast flange near the input of the loop balun was damaged during the installation, but caused no trouble until an arc persisted in the balun. Opening of the balun revealed that a small portion of this cast flange had a sharp point projecting toward the inner conductor of the line, and smoothing of this connection restored normal operation. All this data was forwarded to Continental Electronics by Signal Corps Engineers.

(d) The 300-kw Power Amplifier.

(1) General. Some of the pertinent data that was collected before design of the power amplifier indicated that first, a single tube amplifier would be of prime importance for handling the problems related to parallel resonant impedances

and secondly, if an existing tube would meet the requirements, the high cost of the development of a special tube for this application would be saved. The RCA A2332D, the forerunners of which were the shielded grid triode tubes used in the Jim Creek 1-megawatt VLF transmitter, was chosen for this application. The tube type number was changed at a later date to 6949. Some A.E.C. radiation installations had been using this tube near its strap resonant frequency of approximately 72 mc, therefore there were no problems to be encountered by seal heating or similar circumstances. The A2332D (6949) was a proven tube.

(2) Input Circuit. A standard RETMA 3-1/8 inch 50-ohm transmission line was selected for feeding the 20-kw average power, 40-kw peak power, 4 to 30 mc energy to the input circuit of the 300-kw power amplifier.

A swamping resistor of 50-ohms was originally placed in service at the input to the amplifier. This consisted of six 300-ohm Corning glass resistors in parallel for 50-ohms impedance.

Due to problems encountered during the development, where it was necessary to place resistance within the tank circuit of the input arrangement, two of the 300-ohm resistors were removed, leaving the theoretical 75-ohm impedance in shunt with the total input circuit of the power amplifier. This was done to more nearly match the 50-ohm input requirement of the power amplifier.

The frequency range, voltage and current required for the grid blocking capacitor on the input circuit necessitated that a cluster of Centralab capacitors be employed. It is extremely important, in working with clusters, to keep the first resonance above the second harmonic (60 mc) to ensure no burn-up of the

blocking capacitor due to high "Q" resonant circuits.

Only concentric ring air capacitors are employed for the input pi network on the transmission line side. These capacitors are meshed and unmeshed as the frequency of operation is selected. A study of the mechanical configuration will clearly indicate the approximate 40 inch diameter concentric ring air capacitors on the transmission line side of the input pi network.

Considerable ingenuity was employed in developing the method of obtaining the inductance required for the input pi network. A fixed-characteristic-impedance transmission line with a coil-tapping shorting-device was employed for this application. The amount of inductance required is related to the electrical length of the fixed characteristic transmission line for each of the frequencies of operation.

While operating on 8 mc, the back turn resonance of this shorted transmission line inductance was found to be within the parasitic circuit of the 72 mc. Follow up contacts were put into operation, after first experimenting with the possibility of resistive loading, at 72 mc on the unused portion of the transmission line inductance.

The grid-side capacity of the input pi network is composed of basically the interelectrode capacity of the tube plus some variable-vacuum capacitors in parallel over the lower part of the frequency spectrum.

Only the interelectrode capacity of the tube, 1400 mmf, is required for the input capacity of the pi network throughout the frequency range of 8 to 30 mc. Over the frequency range of

4 to 8 mc, the additional capacity is composed of two Jennings capacitors, each 1200 mmf. This capacity is added to the circuit as a straight-line function from 4 to 8 mc and is not in the circuit from 8 to 30 mc.

The return inductance paths of the two Jennings capacitors were found to be within the parasitic frequency of 72 mc while operating on 8 mc. A breadboard approach was conducted to determine a method of de-Q-ing the residual inductance of the mounting assembly of these capacitors. Powdered iron rings embedded in dove-tail slots, which were cut cylindrically around the capacitors, were used with success in the solution of this problem.

Very low-inductance flat strap leads were employed to connect the shorted transmission line inductance to the grid of the tube. It was found that grid-lead de-Q-ing would be necessary to ensure complete squelching of the 72 mc parasitic which was encountered.

An experiment employing the transmitter itself was conducted. Ten 2-watt, 100-ohm, carbon resistors were placed in parallel to determine the exact minimum resistance required to provide the necessary de-Q-ing of the 72 mc parasitic. When this resistance value was known, an experiment was carried out to scientifically establish a method of inserting the correct resistance at 72 mc with only a minimum of resistance added to the 30 mc operating frequency at the upper end of the band.

Dove-tail slots were put on both sides of the 1/2 inch by 6 inch wide, approximately 10 inch long grid straps. This dove-tail slot was filled with powdered iron resistance material to

give the theoretical resistance for de-Q-ing the 72 mc oscillation.

The input pi circuit was completely enclosed in a sliding drawer mechanism to provide a simple method for tube change. The filament transformer was part of this sliding drawer mechanism and became the socket for the tube. All other hardware is either physically part of the grid drawer or is bolted to the tube before putting it into the socket.

(3) Plate Circuit. The plate circuit is another pi network and is shunt fed.

The plate blocking capacitor was originally conceived to be a pair of teflon-impregnated cylinders approximately 7 inches in diameter and 30 inches long. This work was contracted for to the U.S. Gasket Company and a satisfactory unit was received only after Continental Electronics Mfg. Company had paralleled their efforts and patented a technique of employing irradiated polyethylene as a dielectric material for blocking capacitors.

The plate capacity of the output pi network above the frequency range of approximately 26 mc was essentially the output capacity plus strays of the 6949 power amplifier tube. Over the frequency range of approximately 4 to 26 mc, five Jennings capacitors were connected in a tight ring in parallel to supply approximately 2250 mmf total capacity for the 4 mc operation. During the development of the transmitter, it became necessary to employ a gap on the outside periphery of the ring supporting these capacitors to ensure that any arc to ground would not damage the capacitors. While many hours during the development of the

transmitter were spent studying the resonant impedances associated with the five capacitors in a ring, the final conclusions were that there were no resonances substantially aiding any of the problems associated with completing the development of the equipment.

The plate inductor of the output pi network went through a rather strange evolution to reach its final stage. The original work was for a toroid inductor to provide a transformation of approximately 1 to 1 from the plate impedance to the output transmission line. This is an approximately 150-ohm plate impedance to 150-ohm output impedance.

The turn-to-turn voltage of an inductor for this impedance transformation would be excessive and to ensure satisfactory turn-to-turn voltage of the toroid, early tests were started to find a dielectric material that could be placed between the turns of the toroid to contain the voltage. A silastic rubber extrusion was purchased, on which tests were conducted. The material was found to be extremely lossy and unsatisfactory for a voltage gradient device.

Other factors involved in the development of the transmitter changed the output transmission line impedance requirement to 25 ohms. For this reason, the voltage gradient was reduced and the turn-to-turn voltages involved could now be contained without the use of dielectric material between the turns.

The first toroid inductor placed in the power amplifier for power tests had a large parallel plate of the toroid tied to the plate capacity of the tube, thus restricting the minimum capacity

that could be achieved by the plate tuning control. This was changed in later tests so that the extra capacity became part of the output pi capacity.

A most ingenious method of varying the inductance of the toroid was devised. It employed inner and outer contacts on an exact replica of the top plate of the toroid, driven by four lead screws. The inner contact buttons were of silver-graphalloy content and the connecting straps (to the housing for the contact) were of solid silver. The current was not allowed to flow through the springs pushing on the mechanisms holding the silver contact buttons and heat sinks were employed to remove the heat from the contacts as fast as possible. The adjusting technique ensures equal pressure on all the springs and equal pressure from all the contacts on the toroid. Since a larger surface area was involved, the outer contacts were of the conventional type and originally employed short pressure arms with silver graphalloy contact buttons. Longer arms were installed prior to shipment of this transmitter to the first installation site.

The toroid inductor was designed to make separation and removal as easy as possible because of the complexity of its mechanical configuration. Finger contact plug and socket assemblies were employed to connect the toroid plate inductor to the plate pi capacitor and the output pi capacitor of the output pi network. The toroid coil could be cranked in and out of these finger stock arrangements.

The original shorting plate was supported by a G7 doughnut ring. During the development of the amplifier, this G7 ring

received the full force of many arcs related to parasitic and voltage build-ups within the toroid. Although these arcs were eliminated during the development of the amplifier, it was deemed necessary to provide a different method of supporting the shorting rings. A solid brass ring with a ceramic insulator support above the plate was designed, and later the ring was lightened by cutting out as much material from the ring as possible.

Throughout the power testing of the 300-kw power amplifier, the possibility of water cooling the inner turns of the toroid was considered. In lieu of this consideration, after power testing was completed in the manufacturing facility and before shipment to the installation site, a loop of copper water tubing was silver soldered to each of the 12 inner turns of the toroid. This was done to ensure an easy method of water cooling the inner toroid turns if proof of performance tests indicated that it was necessary. To complete the water path, it was necessary to supply fittings in parallel with the water flow to the first section of the plate rf choke.

The toroid inductor was connected to the plate "C" capacitor at two points. From each of these two points, two paths of the toroid inductance were connected, one to the left bank and one to the right bank of the load capacity. The toroid inductance was therefore constructed in four equal segments of approximately three turns each.

With a new output impedance of 25-ohms, made possible by other major circuit changes during the development of the transmitter,

Jennings vacuum capacitors of 15-kv peak rating could be employed for the output pi capacitor of the output pi network. Four capacitors, each with a maximum capacity of 800 mmf, are used on each of two sides for a total capacity of 6,400 mmf.

A 50-ohm transmission line connects in as short a path as possible from each of the two banks of load capacitors to a common point at which a 25-ohm line feeds to the output network. The evolution of this feed system is described in the output network section of this report.

Only the residual inductance of the toroid tied the two halves of the load capacity together during the original power tests. The effect of the cross-over frequency was encountered while operating on approximately 14 mc. The voltage from the load capacity to ground would rise to a high value and cause arcing and sometimes damage to the capacitors. The cross-over was caused by the residual inductance and the inductance of the two 50-ohm lines tying together and resonating the load capacity at a harmonic frequency. This frequency would have a high "Q" resonant circuit associated with it, not loaded by the dummy load or by the matching network of the equipment.

Several power experiments were conducted to determine a method of controlling, or effectively de-Q-ing, the balance. Some of the first experiments included the use of Globar resistors and capacitors to move the resonant frequency out of the band as well as to de-Q it. Since the inductance of the resistors was still too great, Corning glass resistors were tried. Here again, the wattage capabilities for an air cooled resistor

was not sufficient to dissipate the generated energies from this cross-over effect.

Theoretically, a third inductance value much less than the other two inductance values would essentially raise the resonant frequency above the second harmonic, or at least put it in a position so that no further cross-over effect would be encountered. The finally-successful cross-over resonance destroying device comprised two flat straps very close to ground with powdered iron on the surface of the strap adjacent to the ground.

One of these straps was placed on the front edge of the cabinet tying the two load capacitors together. The other strap was placed on the back half of the capacitors to tie them together. One of the most serious problems encountered during the development of the transmitter was the 43 mc harmonic frequency while operating on 21.5 mc. At one stage of the development, it was found there was a greater second harmonic energy than fundamental energy being coupled to the dummy load.

While it was determined at a later date that this was caused by a combination of factors, the major factor was the very low second harmonic impedance of the plate to ground capacity which was essentially tying the outer shield of the toroid conductor to ground. This outer shield began to act like a quarter wave open stub, developing rather high potentials on the top section of the toroid and causing arcing to ground and to the top of the cabinet. It was an unworkable arrangement.

One of the experiments conducted in an attempt to de-Q this cabinet resonance was straightforward capacitive resistive coup-

ling using Globar resistors employed in the circuit to keep them from burning up.

Another test employed the use of iron support channels in place of the aluminum channels which hold the toroid in position. The possibility of tuning these iron channels to 43 mc was investigated. No breadboard tests or the power tests that were conducted using the iron support provided any improvement over the situation.

A single high pass filter technique utilizing two 5-kw Corning glass water cooled resistors was employed. Power tests through the 43 mc harmonic frequency indicated that a little over 5-kw was dissipated at one frequency. A second similar device was constructed in order to halve the dissipation and possibly squelch the harmonic to a lower value, but it was found that the harmonic could not be reduced any appreciable amount by the additional high-pass filter.

Therefore, a single high-pass filter coupled to the circuit through an air capacitor was determined to be the best solution for squelching the cabinet resonance at 43 mc.

During the development of the high-pass filter, indications were that better shielding of all openings would be required. Additional finger stock contact arrangements were made between the top of the shelf and the cabinet as well as to all other openings related to the in and out connections of the power amplifier. The window openings in the front door of the power ampli-cabinet were screened with 1/4 inch hardware cloth to prevent radiation through the glass opening.

The first attempt in the design of an rf choke for this high power application was rather unique. It was a variable rf choke approximately 6 inches in diameter having a length of 12 to 14 inches. Each of the turns over approximately 50% of the coil was loaded with a two watt resistor in the unused back-turn section of the coil. This was used in a single "L" section filter, but was abandoned because it was found to be inadequate for the high voltages that were encountered.

A single rf choke was constructed of rather large wire to carry a large portion of the circulating current of the power amplifier pi network at the low frequencies. This again was employed in a single section fileter and on some frequencies the level of rf energy on the plate voltage lead was found to be extremely high. Two steps were taken at this point of the development to improve the situation. A silver-plated, water cooled first section rf choke was developed, and a second section choke, de-Q-ed by a capacitor coupled Globar resistor, was incorporated. A specially designed Centralab 1000 mmf capacitor was employed for the feed through capacity of the second "L" section filter. The first shunt element was series resonated to approximately 6 mc.

A powdered iron slug was connected to the B/ lead outside the rf cabinet. This was done to destroy any very high frequency harmonic energy tending to go out the B/ lead.

(4) Neutralizing Circuit. The neutralizing circuit employed a variable vacuum capacitor tied directly to the plate of the tube and coupled to the grid of the tube through the grid pi net-

work, which is essentially a 180^{o} phase shifting network.

While the input pi network established the phase shift required, the magnitude of the signal coupled back to the grid was determined by the capacitive reactance of the neutralizing capacitor. Satisfactory neutralization was accomplished by adjusting the neutralizing capacitor while operating at 20 mc and never changing it across the band. The input grid network was always tuned to the operating frequency, thus assuring approximately 180^{o} phase shift.

The lead inductance in series with the neutralizing capacitor was held to a minimum to ensure full frequency coverage without change of the neutralizing capacitor setting.

(5) Feed Back Amplifier. The original calculations indicated that the hum level, using the RCA 6949 high power shield-to-grid triode tube, would be extremely high. For this reason, a feed back system was conceived to reduce the hum level to an acceptable value.

The original concept was for a fixed sample of the output rf voltage to be compared directly to a fixed sample of the input rf voltage on the output 6-1/8 inch transmission line and the input 3-1/8 inch transmission line. Extreme care was exercised to assure that the two samples would be flat with frequency and have corresponding phase characteristics as the transmitter frequency was tuned from 4 to 30 mc.

The early power tests with the feed back amplifier indicated that with the proper adjustment of the rf levels, approximately 8-db improvement of the hum frequency was obtainable.

The first model of the feed back amplifier employed capacitive divider sampling of the two rf energies and coupled the rf sample to the feed back amplifier chassis where the individual grid and plate diode samples would convert the rf to a dc reference level.

Due to the extreme problem of keeping the amplitude and phase of the two samples synchronized, an alternate method was developed with the capacity dividers and diodes mounted in a common housing at the rf sample points. The two dc references were then fed to the feed-back amplifier chassis where a null-servo balanced the two signals and allowed only the unbalanced voltaged to be amplified by the feed-back amplifier. This unbalanced voltage represented the distortion caused by the amplifier and the signal level generated by the ac filament supply, hence a pre-distortion of the grid wave form was accomplished by applying this reference level to the dc bias lead of the power amplifier circuit.

(e) The Power Supply for the 300-Kw Amplifier.

(1) High Voltage Rectifiers. A study of the state of the art for solid state rectifiers was made; however, the system selected employed two rectifier units utilizing type 857-B mercury vapor rectifier tubes.

Each rectifier unit was rated at 9-kv and were connected in series for a total output of 18-kv. The primary of the second 9-kv rectifier unit was connected in a delta configuration for all modes of operation. The primary of the first 9-kv rectifier was connected either in wye or in delta, thus the system allowed the voltage to be turned on at the relatively low level of approximately 5-kv.

With the use of the plate regulator that adjusts both of the rectifiers, the voltage could be moved smoothly from the 5-kv reference to 7-kv, then switched from wye to delta to increase the voltage from 7 to 10-kv. The second rectifier was applied at a 7-kv reference at at 5-kv on the first rectifier for a total of 12-kv; then the voltage could be increased to the level of 20-kv.

Since mercury vapor tubes were employed, the air system had to provide heat when the temperature dropped below 35C on the mercury condensation point of the tubes. This was accomplished by supplying cabinet heaters so that the air flow passed over the heaters, raising the thermostatically controlled temperature of the air to the proper level. No air conditioning was required since the tubes were operating in a mode that allowed temperatures at the sites of operation to have a value in excess of the ambient temperatures required by the specification for this transmitter.

The physical arrangement of this rectifier comprised a cabinet for each of the 9-kv rectifiers, a filter rack and grounding switch arrangement, the plate regulator, the plate transformers and the plate choke.

Each of the main rectifier cubicles contained a spare type 857-B rectifier tube and auxiliary items.

The filter-capacitor and grounding-switch rack contained the limiting resistors, the stop-start capacitor charging arrangement, the thyrite protection for the power amplifier filter choke and auxiliary items.

The six plate transformers and one plate choke are mounted outside the main transmitter equipment.

(2) Crowbar Protective Circuit. The RCA engineers recommended that a very high speed electronic crowbar protective device be employed in the B+ service to the type 6949 power amplifier tube. The state of the art at the onset of this development indicated that a thyratron crowbar would be the most economical and reliable approach. Continental Electronics had proven successfully that, at 15-kv dc operation with proper control of peak currents and voltages, a good high speed crowbar could be developed.

During the installation phases at Woodbridge, Virginia, a problem was encountered with the crowbar circuit. A different manufacturer could not build thyratrons having the hold-off characteristics of the Machlett 405-B thyratron.

(3) Power Amplifier Bias Power Supply. A conventional unregulated bias supply was designed for use with the power amplifier stage. This supply, when originally designed, was controlled only by taps on the main plate transformer. During the development of the equipment, a Variac was installed to adjust the bias voltage from zero to approximately 350-volts-negative to provide an exact operating load line for the power amplifier tube. A double "L" section filter was employed on the supply to ensure a negligible hum component output.

(f) The Control Circuit. The proper control voltage (48 volts dc) and the method of properly interlocking the voltages in excess of either 50-vdc or 115-vac were the subject of many hours of discussion before the control circuit was finalized. A 48-volt dc control bus was employed for interlocking and contactor operation. A nominal 440-volts was selected for a primary ac

voltage. Each major control branch had a 460-volt distribution circuit breaker followed by a 48-volt dc operated contactor. The contactors of these distribution systems were interlocked for the proper sequence of operation.

(g) The Key Interlock System. A Kirk-key interlock system was designed to ensure maximum safety. This Kirk-key system will allow access to areas where the exposed voltages are not in excess of the specifications of the contract. There are lethally dangerous voltages in these areas which are exposed if protective covers are removed.

Basically, the system is divided into two sets of keys, those for opening doors with only the high voltage and bias removed for such operations as checking the filament voltages and currents, and those for opening doors with all voltages removed, allowing access through any of the doors.

The operating nerve center for the control circuits is the front panel of the control unit itself, located to the left of the power amplifier unit. The front door of the control unit is not interlocked with any of the other equipment; therefore, the door can be opened for examination of such equipment as relays and servo amplifiers.

(h) The Servo Tuning System. Many servo systems were discussed and considered. A general philosophy in the original concept of manufacuring this transmitter was to follow the techniques employed in the AN/FRT-22, which used a servo system of interlocked relays to drive the motors.

The 300-kw amplifier employed heavy loads which required extremely large motors. A one-tenth horse power motor was selected to drive each of the tuning elements of the 300-kw equipment. It was thought necessary to employ a method of proportional control to the servo system in order to meet the specification of tuning from one end of the band to the other in a minimum of two minutes. The load current of the dc motors necessitated paralleling thyratrons for proper power to drive the motor. The major obstacle in such a system was to reduce the "motor-boating" which was due to the interactions of the thyratrons upon each other.

This system was finally discarded for a system using interlocked relays. The servo system, therefore, was operated by a very simple ac reference for on-off control of either the "raise" or "lower" relay.

It was found necessary, during some of the high-voltage, high-power operation of the transmitter, to de-sensitize the sensitive relay that selected the "raise" or "lower" control relay of the servo amplifier. This was accomplished by employing semiconductors to remove "hash," eliminating servo motor hunting.

(i) The 300-kw Dummy Load. The 300-kw dummy load was originally conceived to be a device capable of selecting any of the combinations of 2 to 1 vswr over the nominal output impedance of the transmitter. The evolution of the output impedance of the transmitter has been discussed in a previous part of this report. Basically the work started for dummy loads, simultaneous with the work started for the 300-kw power amplifier, was not all directly applicable to the final selection of transmission line impedances.

The original concept of the dummy load was that of a lossy transmission line of balanced conductors. The nominal impedance of the lines was to be 200-ohms balanced. An individually tuned balanced network was designed, installed and power tested to provide a method of tuning the balanced 200-ohm load over the 2 to 1 vswr range of a 600-ohm nominal impedance device.

Some of the original design concepts of the dummy load were necessarily deleted as the balanced 600-ohm nominal impedance output was reduced first to 440-ohms possibly, then to 300-ohms balanced, and finally to 75-ohms single ended, then 50-ohms single ended. The balanced "L" networks were removed and the loads were paralleled in an attempt to use it as a 50-ohm nominal impedance dummy load. Since the basic concept of such a load is a dissipation type transmission line, it was found that certain hot spots would occur with extreme heating and voltage breakdown problems being encountered while operating on different frequencies.

When tests indicated that the first concept of a powdered iron dummy load would be unsuccessful in a broadband application, a new effort was started employing Corning glass resistors. A 36-inch length of double tough pyrex tubing six inches in diameter was coated with a carbon film and silvered at each end. Water was spiraled through the resistor to scrub the surface of the carbon film resistance material to prevent any spot-heating of the resistive element. Two resistors were employed in the dummy load, each resistor being 100-ohms to ground; therefore, the load is usable as a 200-ohm balanced load, or a parallel arrangement could be incorporated to supply a 50-ohm nominal

impedance. There was no change in dummy load cooling equipment in converting from the powdered iron distributed load to the Corning glass film resistor type load. The Corning glass load required 100-gallons per minute of cooling water flow.

(j) The Water Cooling System. Selection of a water cooled power amplifier tube made a water cooling system for the 300-kw hf amplifier necessary. The original interpretation of the specifications stipulated that rather large cooling room equipment would be required if the 122F capabilities had to be maintained at an altitude of 10,000 feet. After a thorough investigation by Signal Corps representatives and Continental Electronics, the maximum temperature at the 10,000 foot level was compromised.

With the maximum temperature established, a radiator approximately 16-feet long and 8-feet high was designed comprising three units. The two radiators were cooled by two thermostatically controlled fans. One fan was put into operation when the water temperature reached a certain level and both fans were put into operation when the water temperature increased to a level above that which was necessary to maintain a water temperature below 158F at the output of the power amplifier tube.

The transmitting equipment was developed in the Continental Electronics Dallas plant. Existing water cooling coils were used during plant tests; therefore, it was not until the installation of this equipment at Woodbridge, Virginia that the bulkiness of the radiators became apparent. Due to its physical size, a radiator 16-feet long, 42-inches wide and 1-foot deep is impractical for installation and handling by men. A more practical

physical size could have been employed without sacrifice in cooling capability by using six radiators in two banks of cooling coils 8 by 8 feet each. A direct comparison of the cost of the two systems was not made, but it was thought that the savings in the problems of shipping and handling merited the reduction of the size of the radiators.

From past experience, it was necessary to employ a 1500-gallon water storage tank. This would allow approximately 15 minutes of pumping before actual water loss would affect the power amplifier circuit.

The problem of freezing water bursting radiator coils and other associated equipment was given particular attention. The installation group of the Signal Corps designed a water cooling room that employed the available room temperature to heat the coils. It was their design that included motor operated sliding garage doors to keep the cold air out until the radiator temperature reached a satisfactory level. Where building heat is used to maintain the cooling coils above freezing, it is most imperative that the building heat be maintained throughout subfreezing temperatures. Some of the water cooling coils burst during an outage of the steam heat which was available in the pump room after the installation of the equipment. Electrical space heaters were employed over the face of the radiators at this time to help maintain the temperature above freezing in case of steam failure.

Experiments with the use of ethylene-glycol as a coolant with anti-freeze capability for similar tubes have been conducted since that time on other applications of similar amplifiers. These

experiments have not been conducted on the 300-kw transmitting equipment to date, but should be concluded within the next winter or two. It is thought that only a slight reduction in the capabilities of the equipment will have to be made to use ethylene-glycol as a coolant. It should be pointed out that the use of ethylene-glycol does not preclude maintaining the cooling room at a proper maintenance and operating temperature level of personnel.

1.4 The 40-Kw Alternate Amplifier

(a) The Power Amplifier Modifications. In lieu of the push-pull stage employing six Eimac type 3X2500 tubes, a single type ML6427 triode tube was chosen. The primary objective here was to eliminate the complexities of paralleling resonances by employing a single tube.

The original amplifier was designed with push-pull input and push-pull output. The new circuit configuration was a balun for use on balanced input characteristics, but a single ended output was employed. The input balun was of the parallel transmission line design. No tuning or changing was required throughout the complete operating spectrum. The balun was fed directly from the modified AN/FRT-26 section of the modified AN/FRT-22 equipment.

The single ended portion of the balun was directly coupled to the cathode coil of the type ML6427 power amplifier tube. The cathode coil was anti-resonated by two variable Jennings vacuum-capacitors that were mechanically ganged to the sliding arrangement of the cathode coil. In this manner, the input circuit was always resonated for a pure resistance terminating the balun device. The filament leads for the ML6427, which was a directly

heated tube, were passed on the outside of the "U" shaped conductor of the cathode coil; therefore, the choking action was accomplished by the filaments passing through the cathode coil and only a minimum of rf bypassing was required at the bottom of the parallel resonant cathode circuit.

The plate circuit of the alternate amplifier consisted of the conventional pi-"L" arrangement with shunt feed. The plate blocking capacitor was designed using G7 as a dielectric material. G7 was selected after a study of the necessary paralleling arrangement of existing ceramic capacitors and of the problems involved in the use of layer-wound sheets of teflon.

The rf network of this equipment (after the plate blocking capacitor) comprised the pi and "L" configuration mentioned previously, with the three elements of the pi and part of the "L" network capacitor ganged together.

A single Jennings variable-vacuum-capacitor was employed for the plate to ground capacity of the pi network. The output capacity of the pi network and the "L" network was composed of two Jennings variable-vacuum-capacitors. The common housing provided for the plate capacitor and the loading capacitors assured a circulating current return path of minimum inductive length.

Flemished, or spiral coils rather than conventional air-wound coils were chosen as the plate and output inductors. A major reason for such a design was the physical space required; that is, the form factor of these spiral coils could be contained within the cabinet space available.

The B+ was coupled to the tube of the power amplifier stage through a double "L" section filter which removed all rf from the

B+ lead. It was found necessary to provide some high frequency loading of the bottom end of the rf choke. This was accomplished by tapping the Globar resistor up a few turns from the bottom of the choke.

A slug of powdered iron was used in parallel with the lead coupling from the plate of the tube to the first Jennings capacitor of the output pi network. The powdered iron core dissipated any high frequency energies and kept them from being transmitted on through the equipment.

In addition to these devices, a harmonic filter was placed in the 3-1/8 inch output transmission line. This filter was of the low pass type and effectively attenuated the harmonics.

An output vswr indicator was provided in the output section of the 3-1/8 inch output connector to indicate the type of load into which the transmitter was operating.

The air cooling system of the power amplifier utilized a large cabinet blower to pressurize the intermediate area. The intermediate area, then, was a chamber for supplying air over the plate of the tube. The tube blower was of the compressor type and drew the air down over the filament and grid of the tube, over the plate and out through the top of the equipment. This approximately 20-kw of dissipated heat was ducted from the building.

This company acquired a microfilm set of working prints through the Signal Corps and manufactured a cabinet for the alternate amplifier which was exactly the same as the original amplifier cabinet. The existing front and rear doors and top and side skins were used from the original equipment.

(b) The Power Supply for the 40-kw Alternate Amplifier. The original concept of a power supply for the 40-kw alternate amplifier was the existing power source. It was found later that the necessary signal to distortion requirement could be met only if a higher potential was used. The 9-kv potential required a new plate transformer and choke arrangement. There were no other major modifications of the original power cabinet.

It was necessary to replace the motor operated Westinghouse circuit breakers with Allis-Chalmers solenoid operated breakers in the 40-kw alternate amplifier. This decision was made prior to availability of Westinghouse field modification kits provided to overcome an outstanding problem associated with the re-cycling of the motor operated circuit breakers. The Allis-Chalmers solenoid operated circuit breakers replaced the circuit breakers in the AN/FRT-26 and the alternate amplifier.

1.5 The T409/FRC-30 Western Electric LD-T2 Transmitter Modifications.

Throughout the 300-kw hf development, it was necessary to add only one de-Q-ing device in the LD-T2. This was where the screens of Amplifiers One, Two and Three were fed with identical leads without de-Q-ing devices in the leads. The addition of a small resistor with wire wound around it as a parasitic choke was employed to correct loss of gain in this circuit at one particular frequency.

It was not requested, nor were any of the work orders (that had been established for the Western Electric LD-T2 Transmitter by the Signal Corps) applied by Continental Electronics to the transmitter used as a driver. This did not cause any major

problems, but considerable time was lost by driving the AN/FRT-26 through two single-ended 50-ohm coax lines to the input balun of the AN/FRT-26. This did not provide a good transmission line system to combine the two amplifiers.

After the equipment was installed at Woodbridge, Virginia, it was found that a modification work order, recommended by the Signal Corps would convert the balanced output of the LD-T2 to a single-ended output. This single ended drive system to the AN/FRT-26 was a better arrangement.

1.6 Illustrations

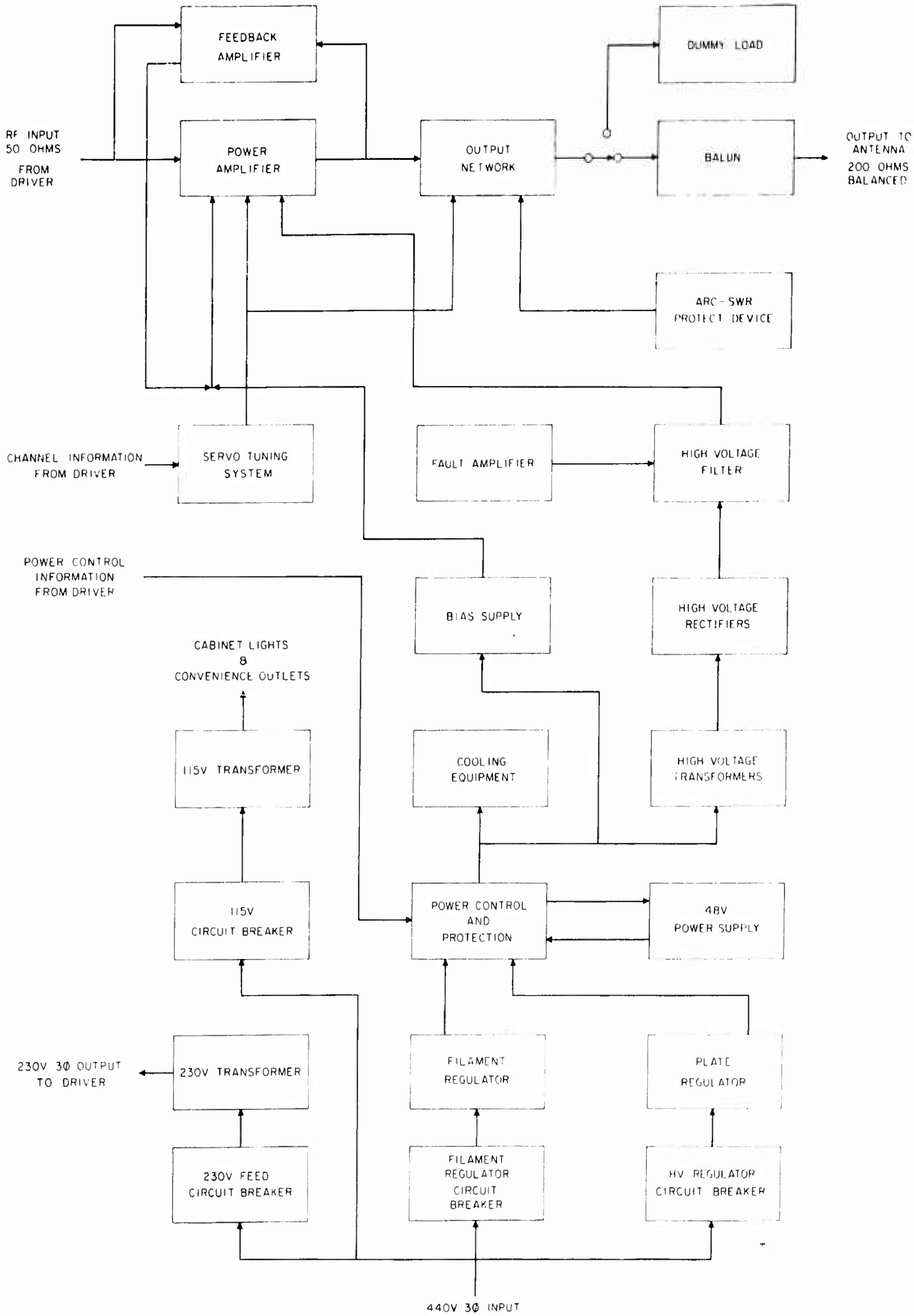


Figure 1. Block Diagram, 300-Kw Amplifier Group.

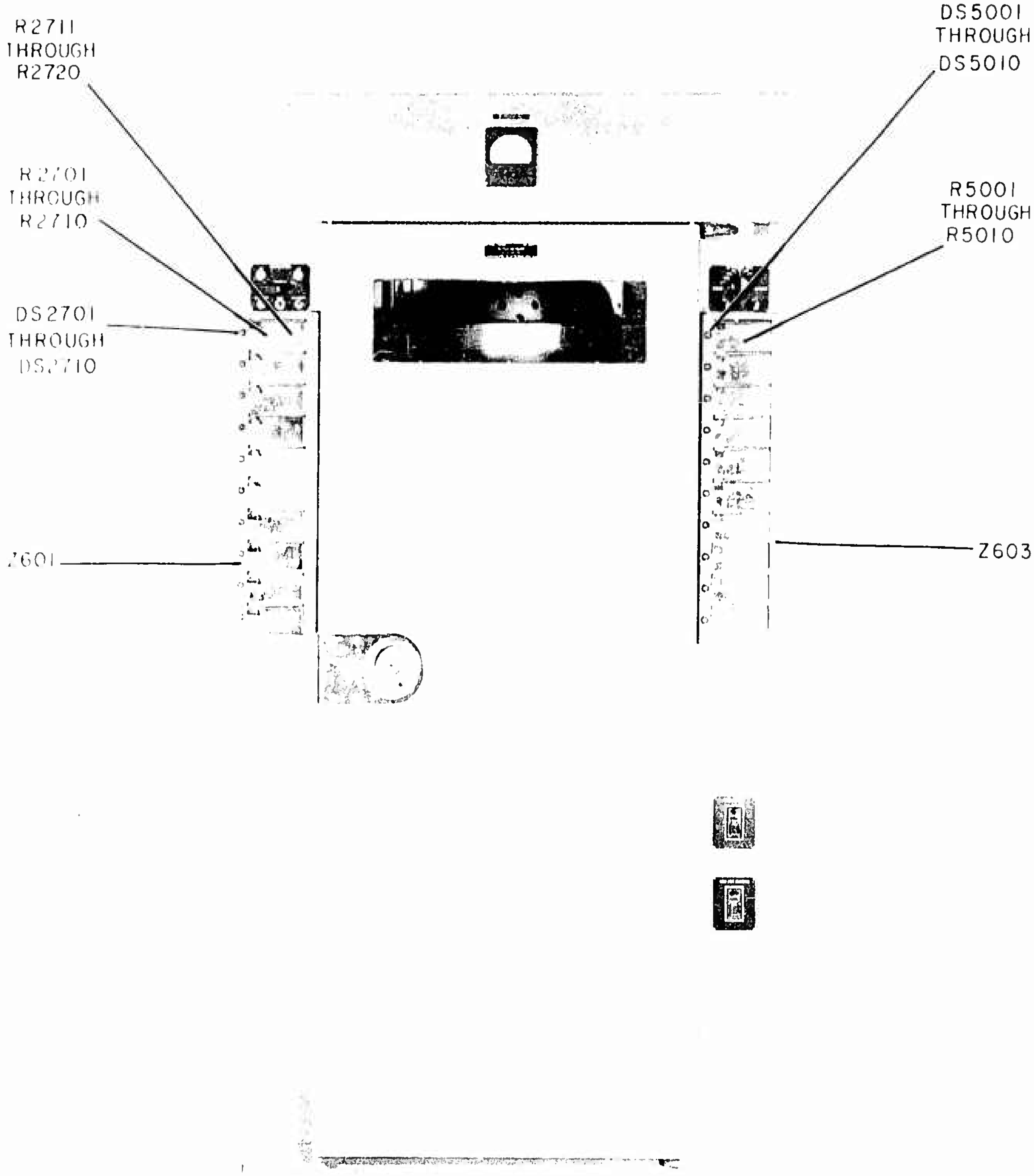


Figure 2. Output Network Unit, Front View.

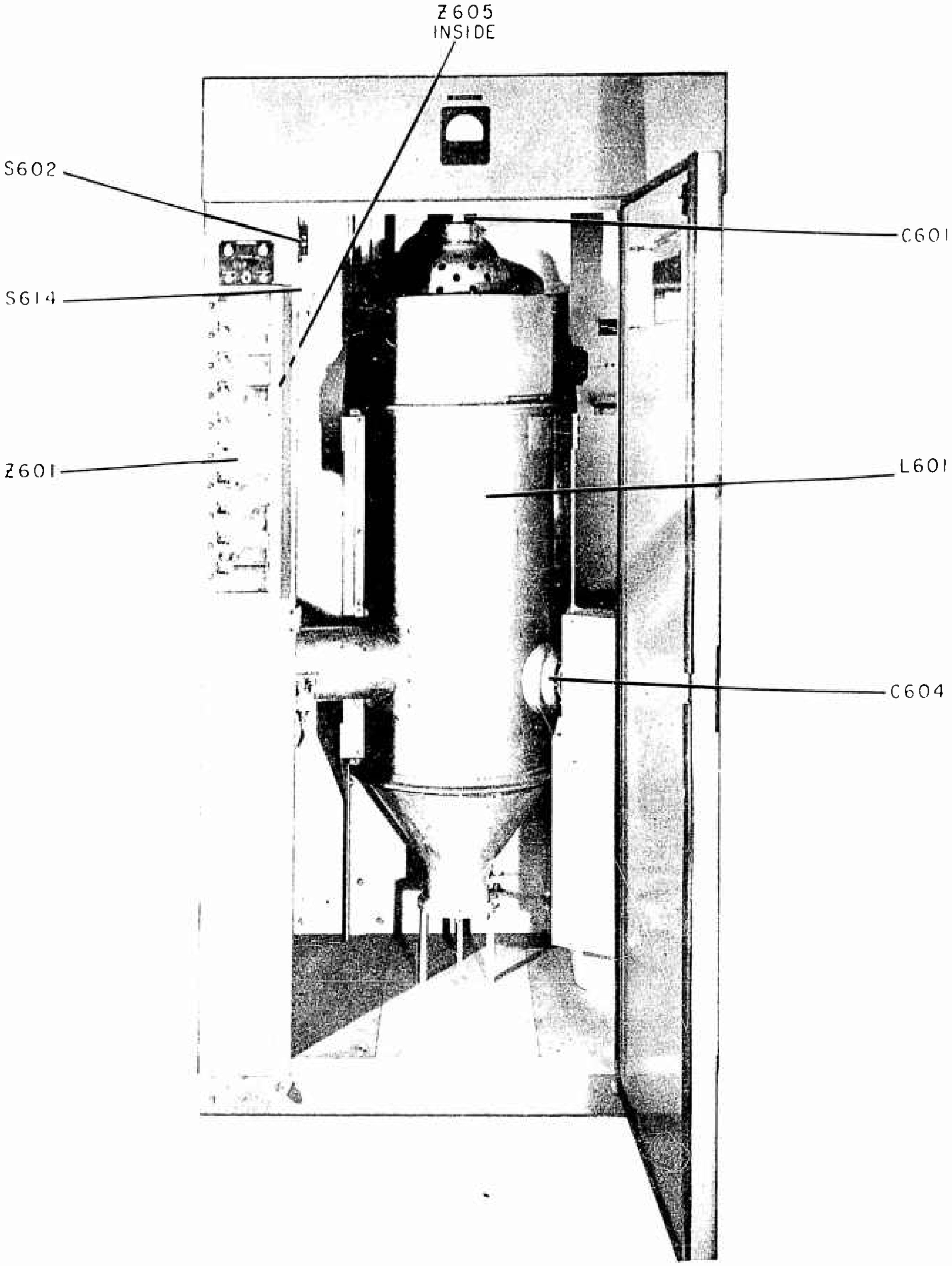


Figure 3. Output Network Unit, Front View, Door Open.

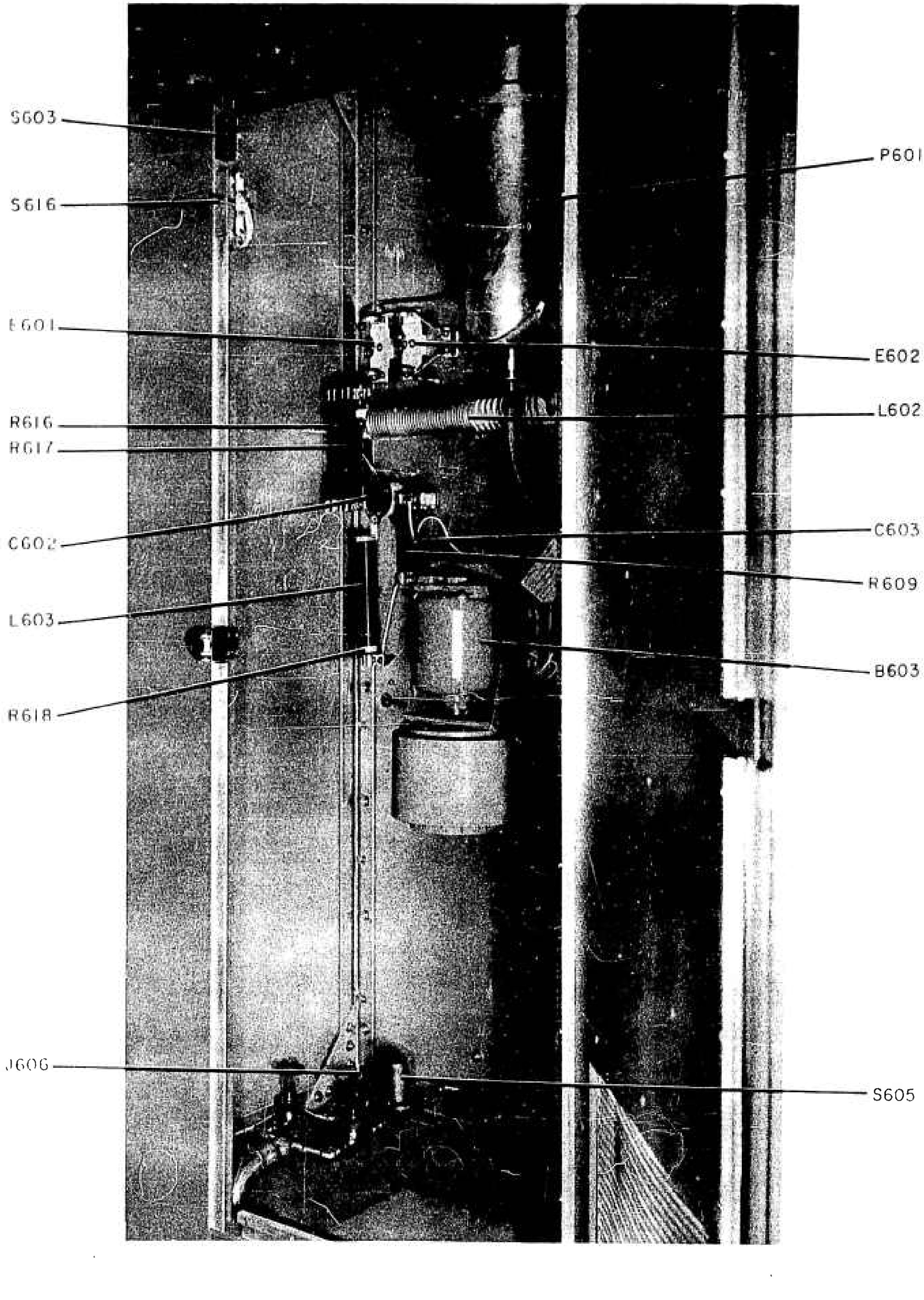


Figure 4. Output Network Unit, Left Portion of Rear Compartment.

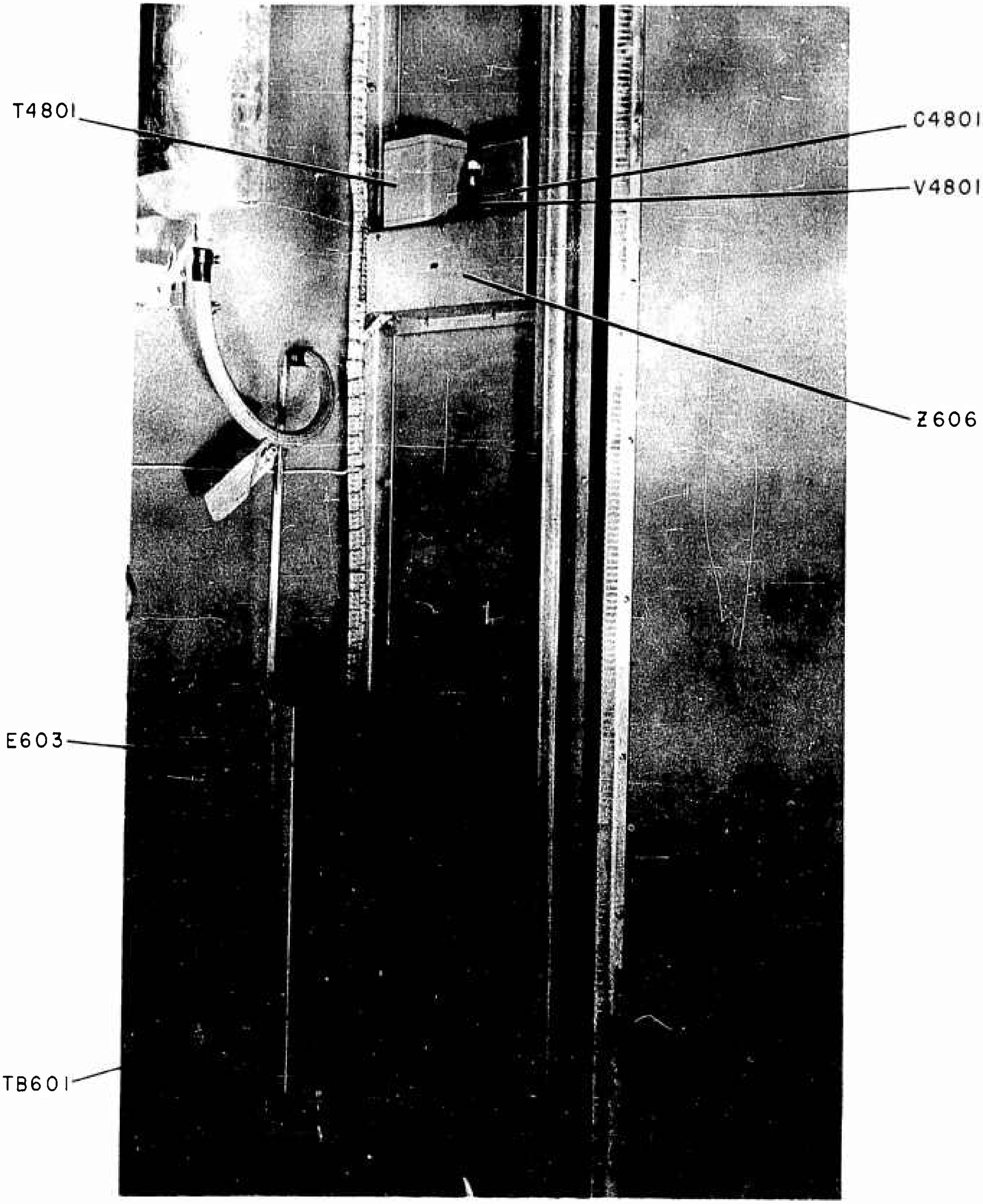
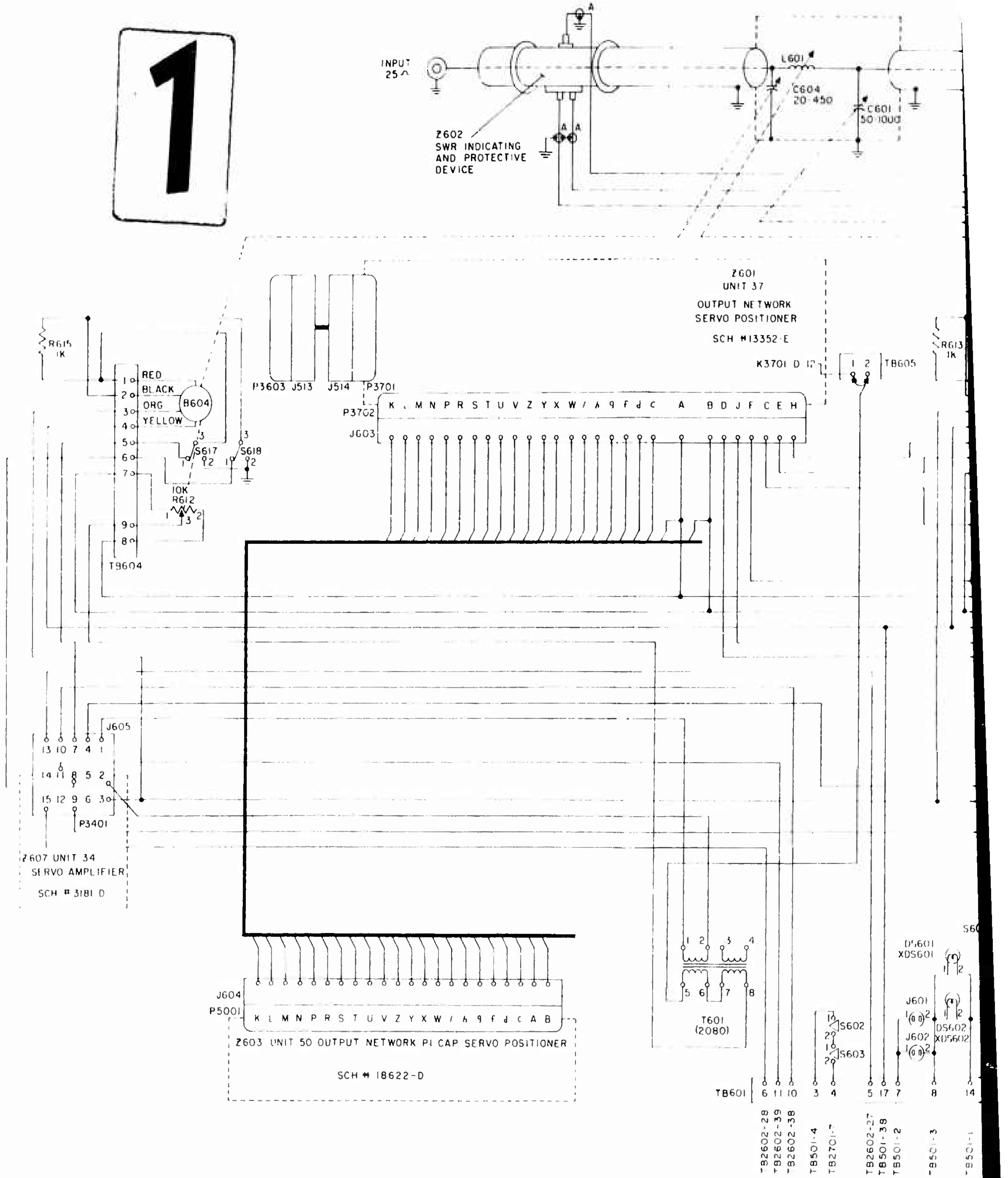


Figure 5. Output Network Unit, Right Portion of Rear Compartment.

1



INPUT 25 ^
Z602 SWR INDICATING AND PROTECTIVE DEVICE
L601
C604 20-450
C601 50-1000
Z601 UNIT 37 OUTPUT NETWORK SERVO POSITIONER SCH #13352-E
K3701 D 17
TB605
R613 1K
R615 1K
RED
BLACK
ORG
YELLOW
B604
S617
S618
10K R612
TB604
P3603 J513 J514 P3701
P3702
J603
J605
P3401
Z607 UNIT 34 SERVO AMPLIFIER SCH # 3181 D
J604
P5001
Z603 UNIT 50 OUTPUT NETWORK PI CAP SERVO POSITIONER
SCH # 18622-D
T601 (2080)
S602
S603
DS601 XDS601
J601
J602
DS602 XDS602
TB601
TB2602-28
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TB501-4
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TB501-38
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TB501-3
TB501-1

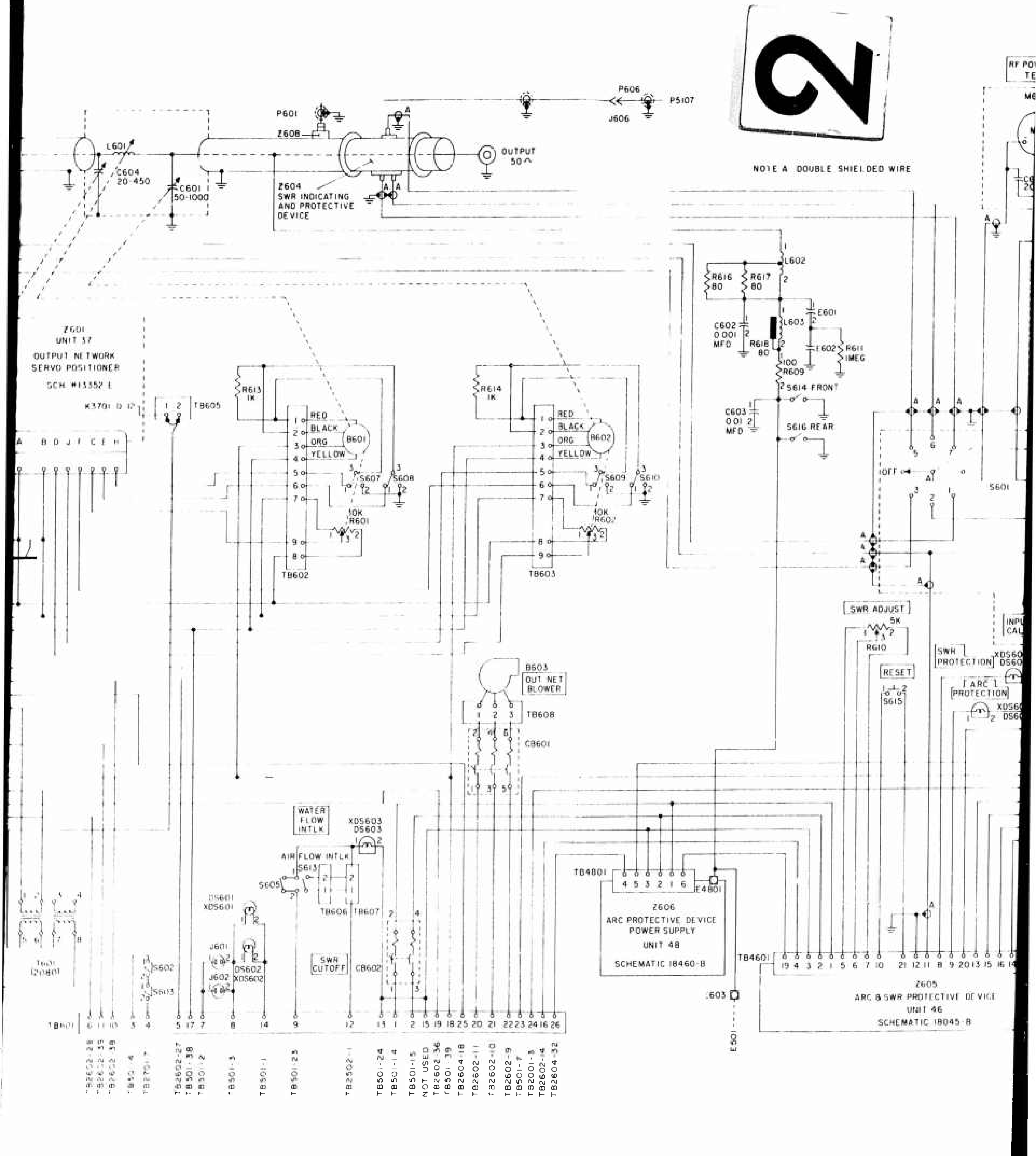


Figure 6. Schematic Diagram, Output

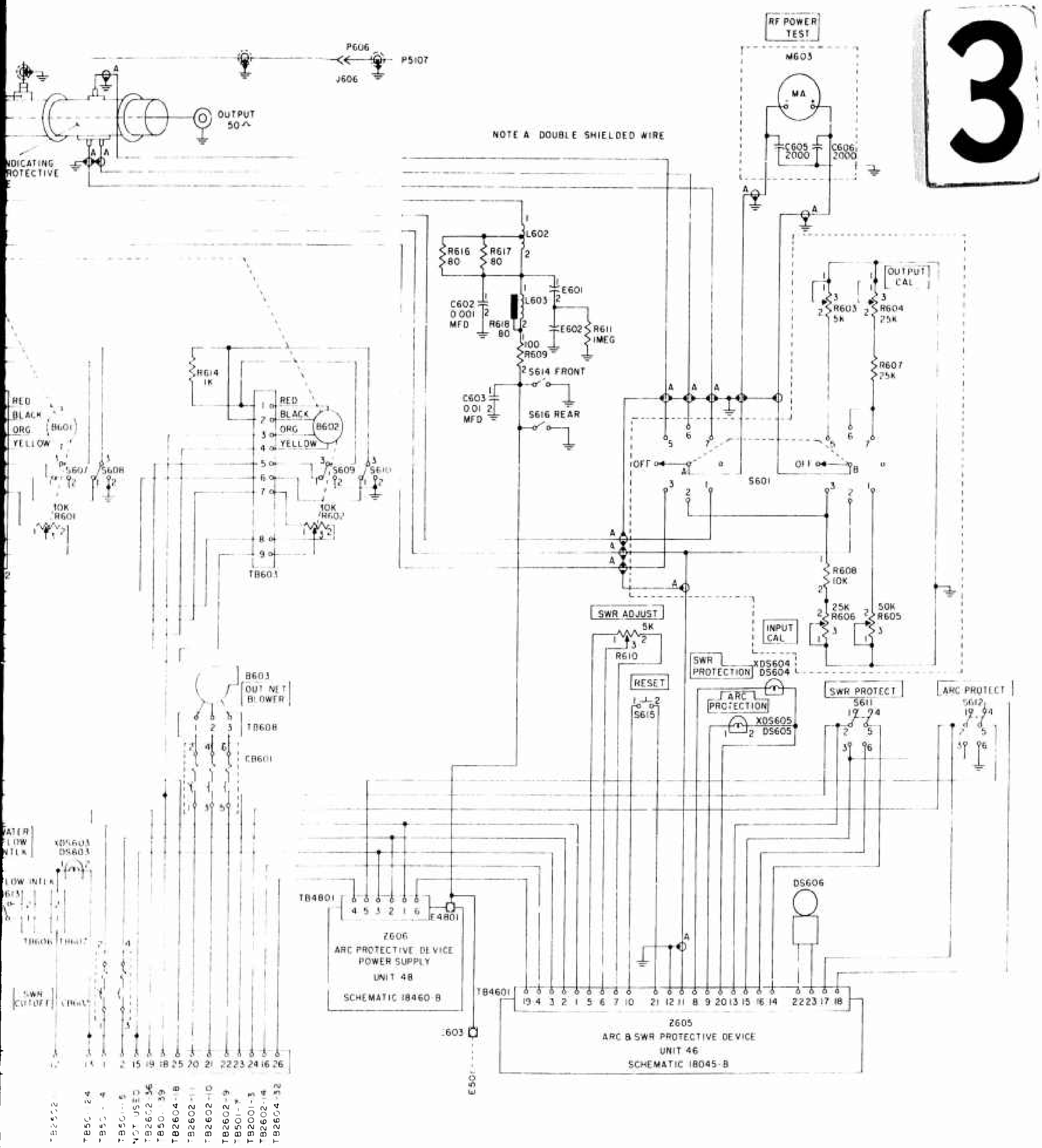


Figure 6. Schematic Diagram, Output Network Unit.

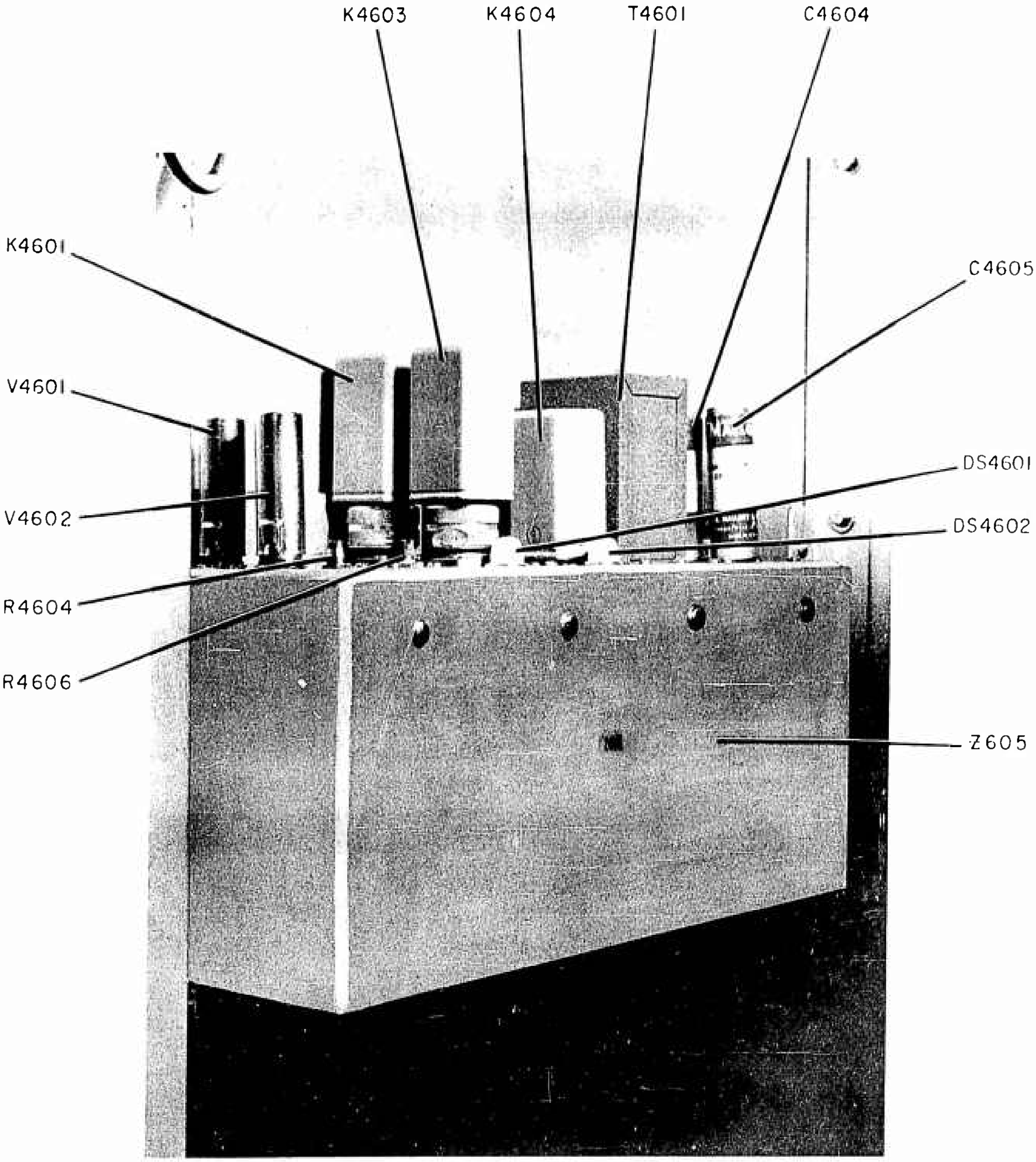


Figure 7. Arc and SWR Protective Device Z605, Oblique View.

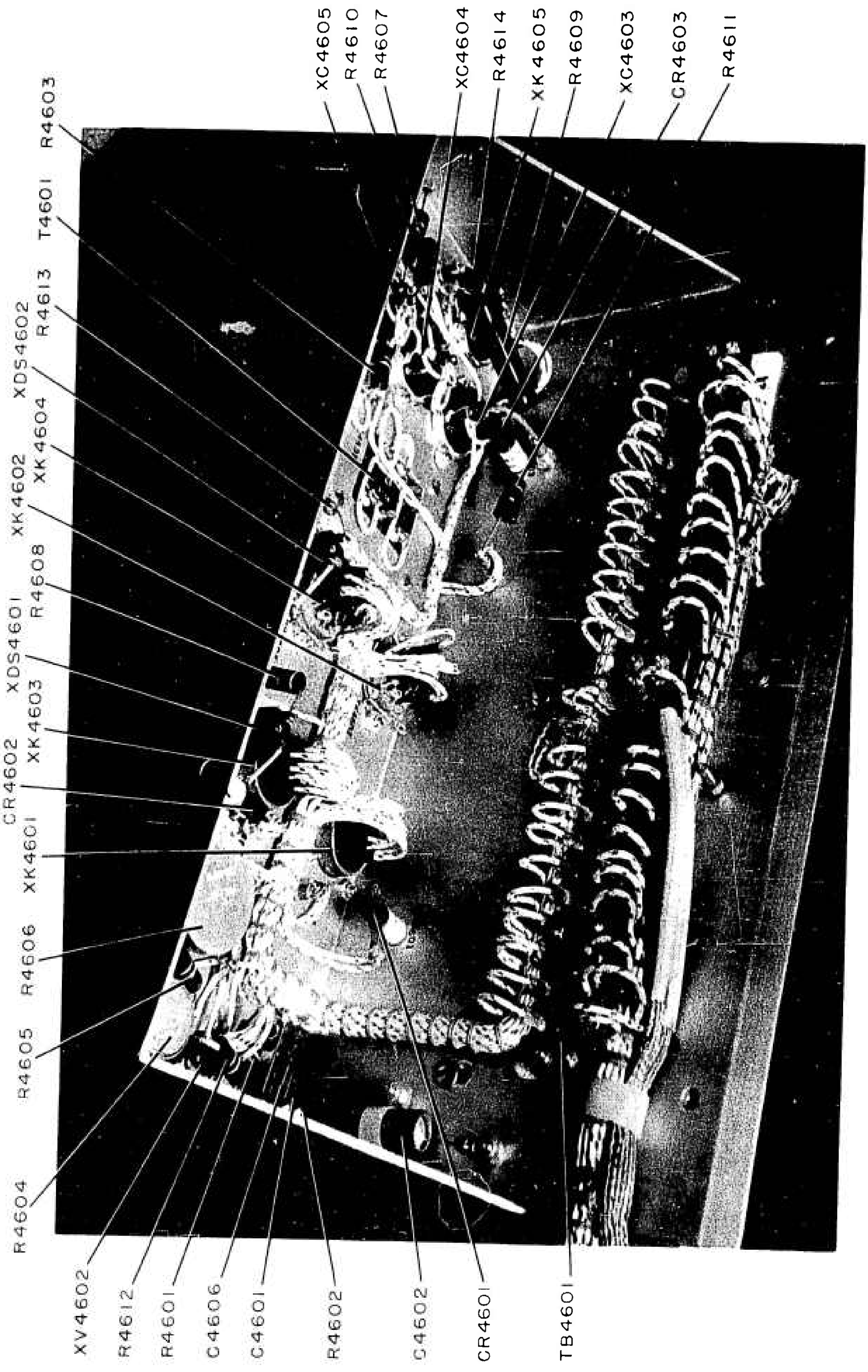


Figure 8. Arc and SWR Protective Device Z605, Bottom View, Cover Removed.

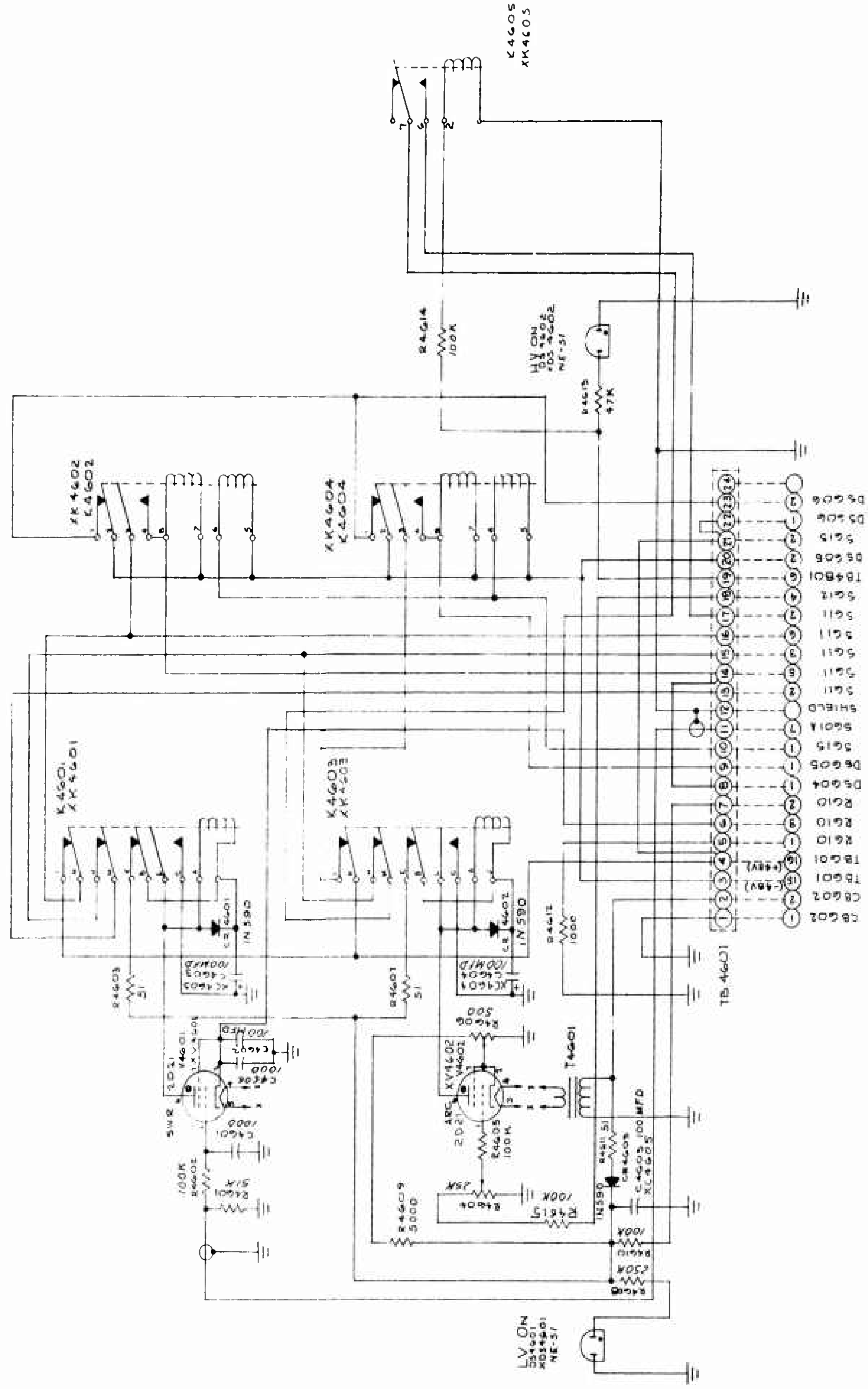


Figure 9. Schematic Diagram, Arc and SWR Protective Device Z605.

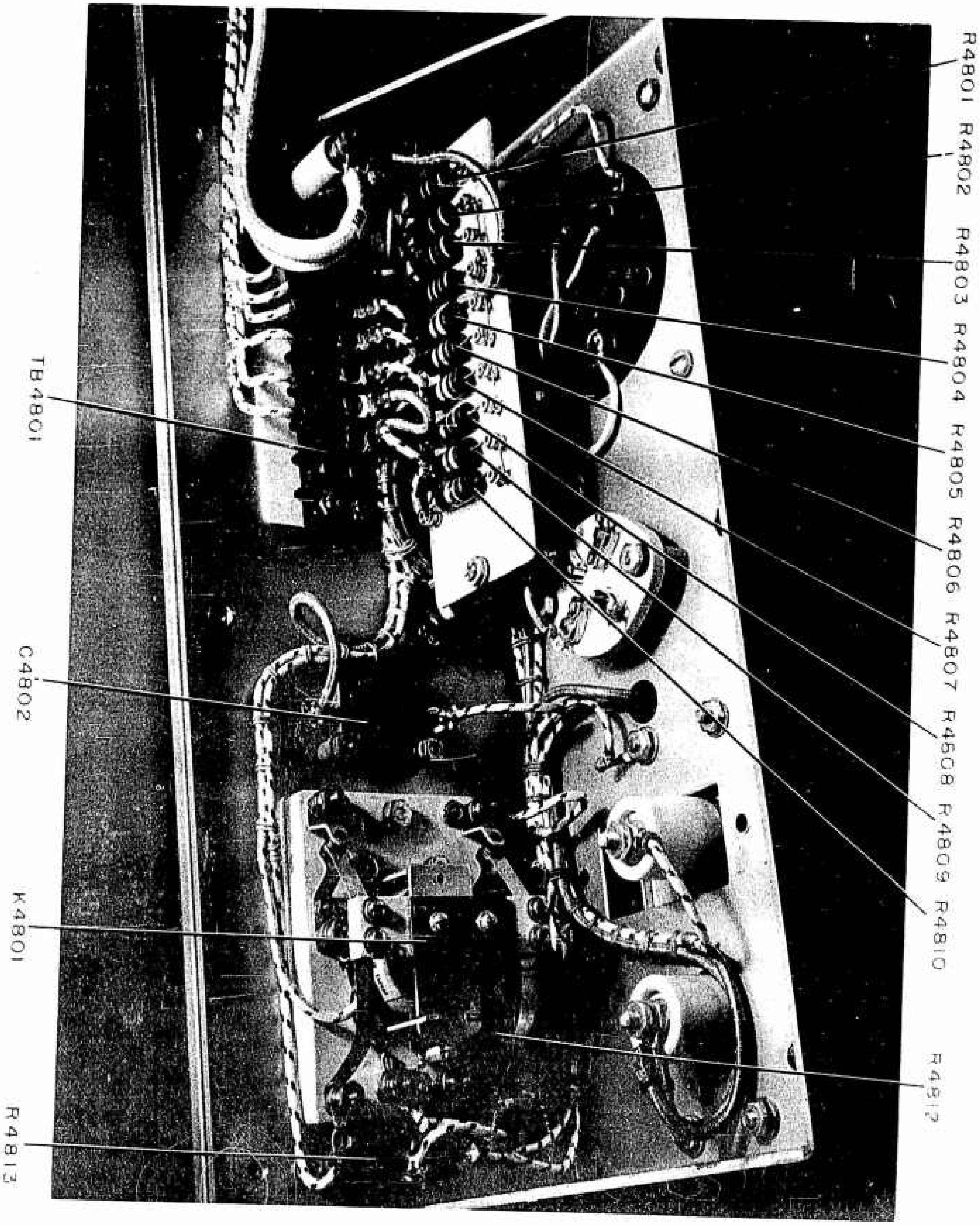


Figure 10. Power Supply Z606, Bottom View, Cover Removed.

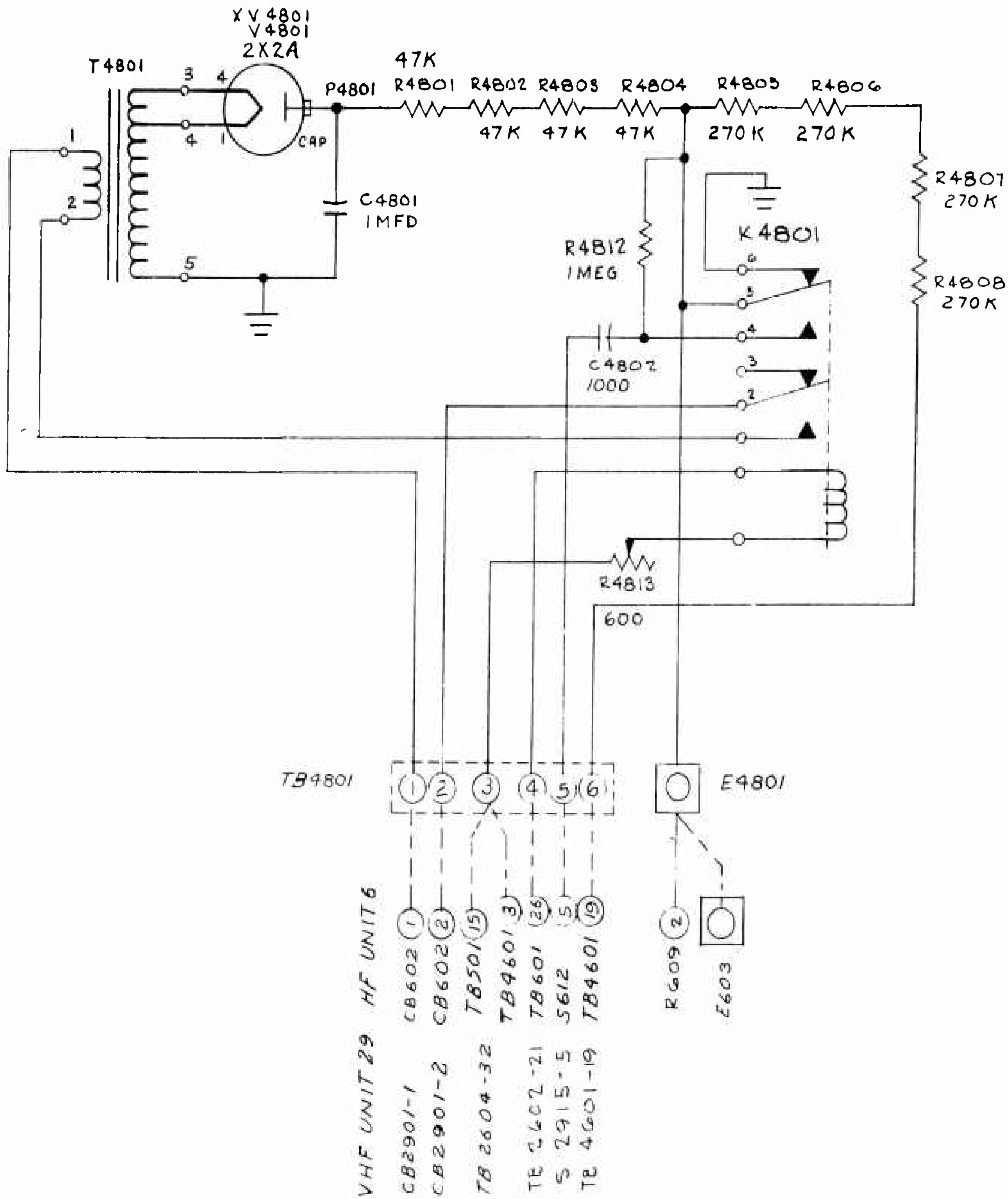


Figure 11. Schematic Diagram, Power Supply S606.

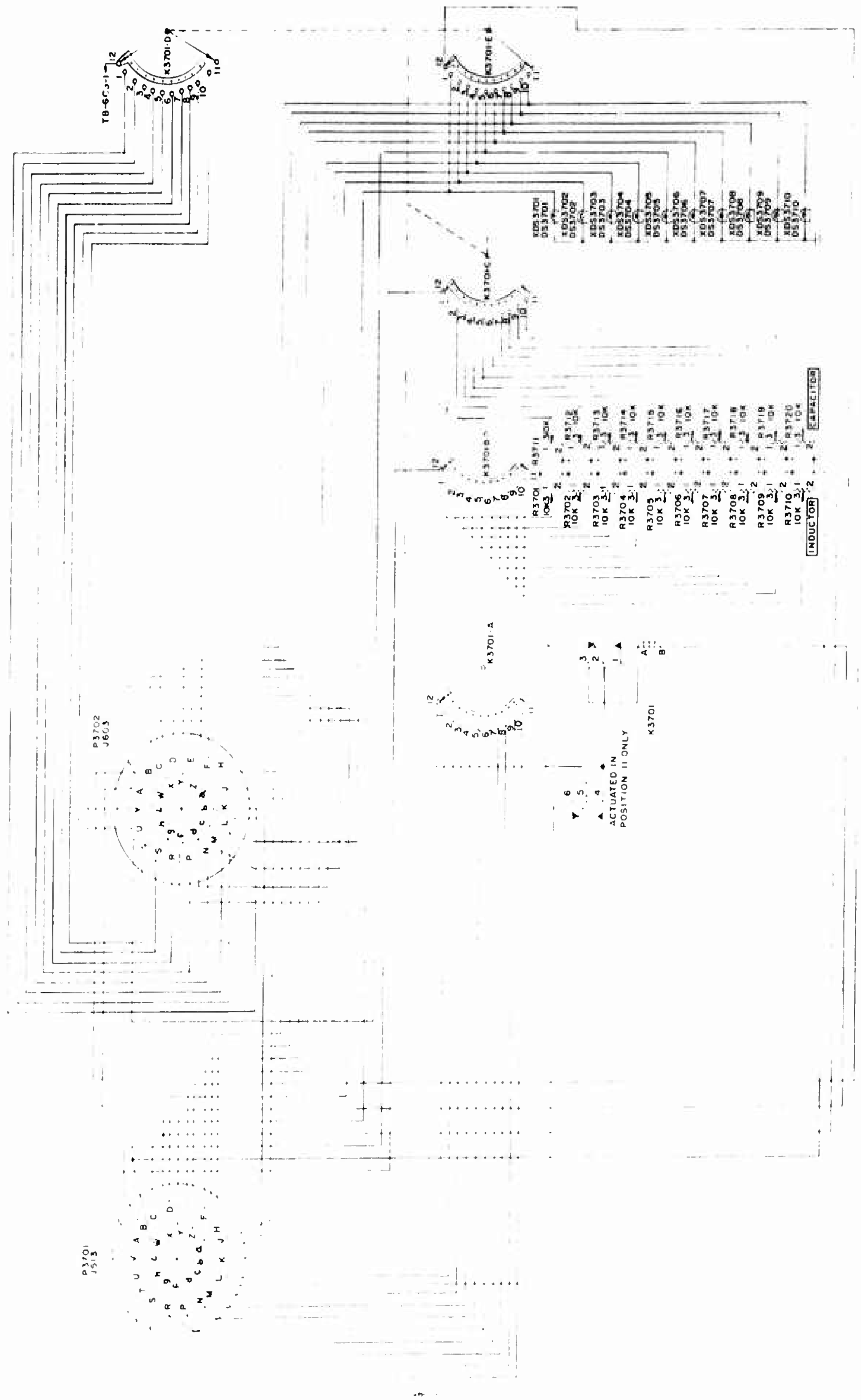


Figure 12. Schematic Diagram, Servo Control Panel Z601.

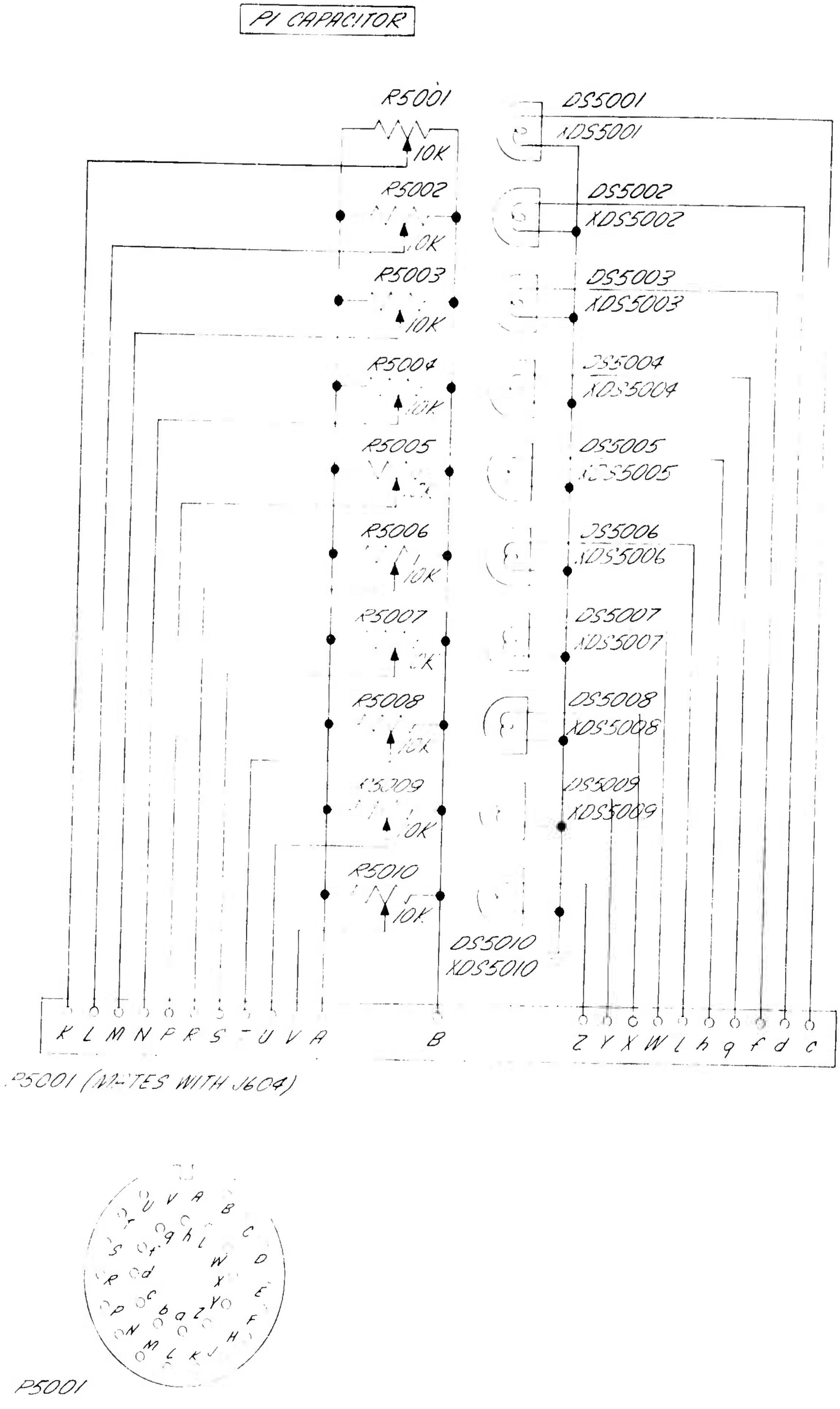


Figure 13. Schematic Diagram, Servo Control Panel Z603.

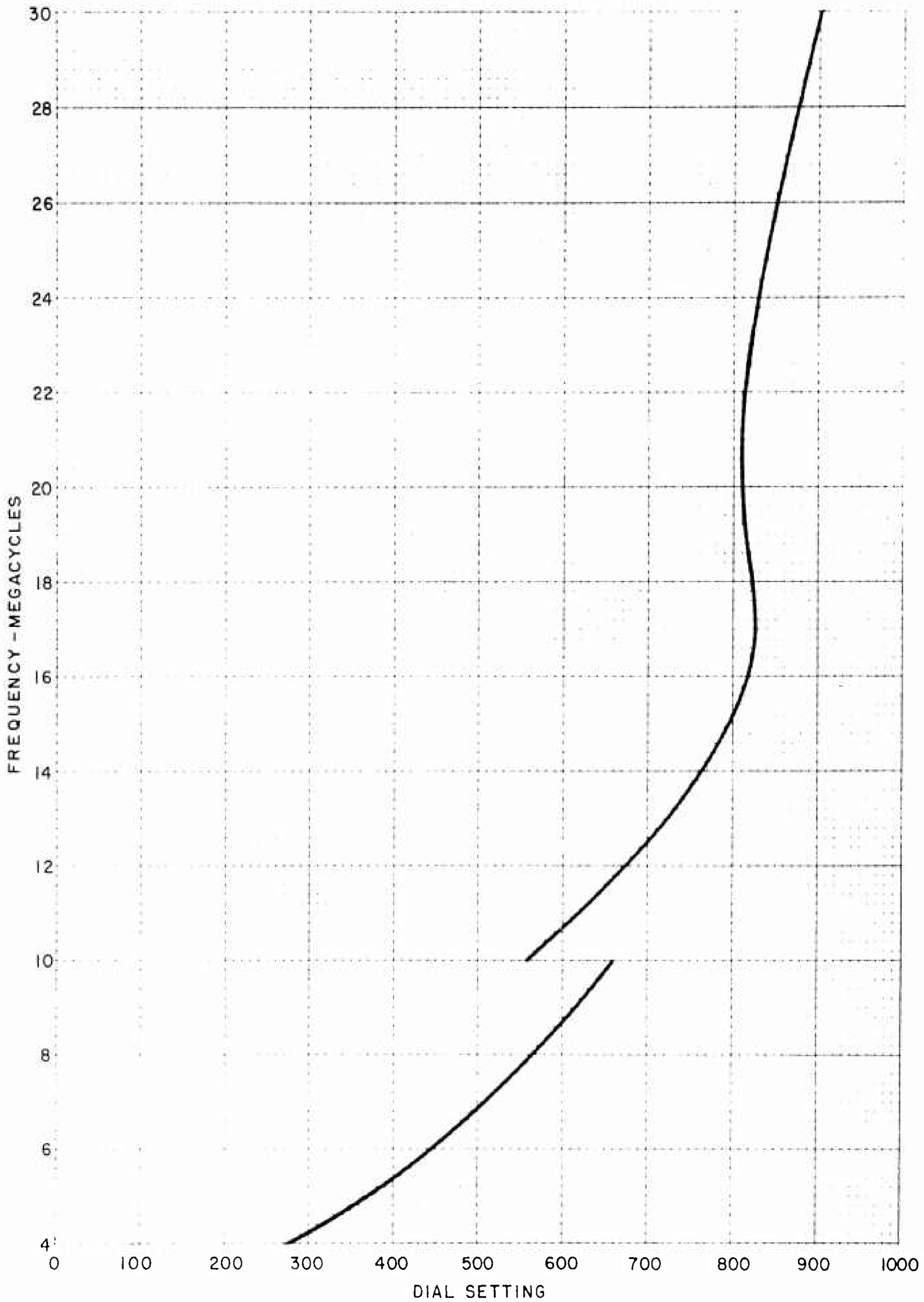


Figure 14. Tuning Chart, CAPACITOR Servo Control.

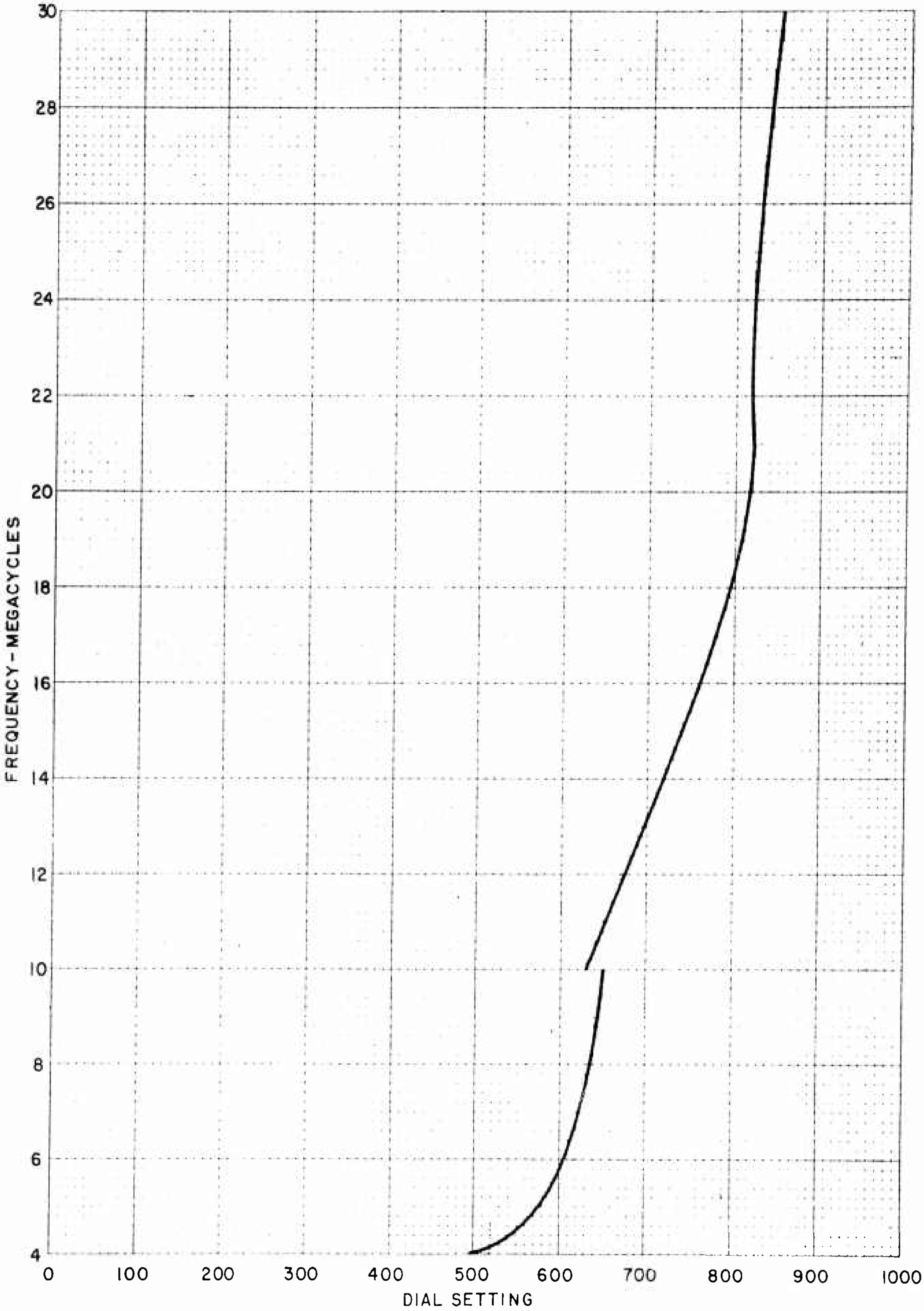


Figure 15. Tuning Chart, INDUCTOR Servo Control.

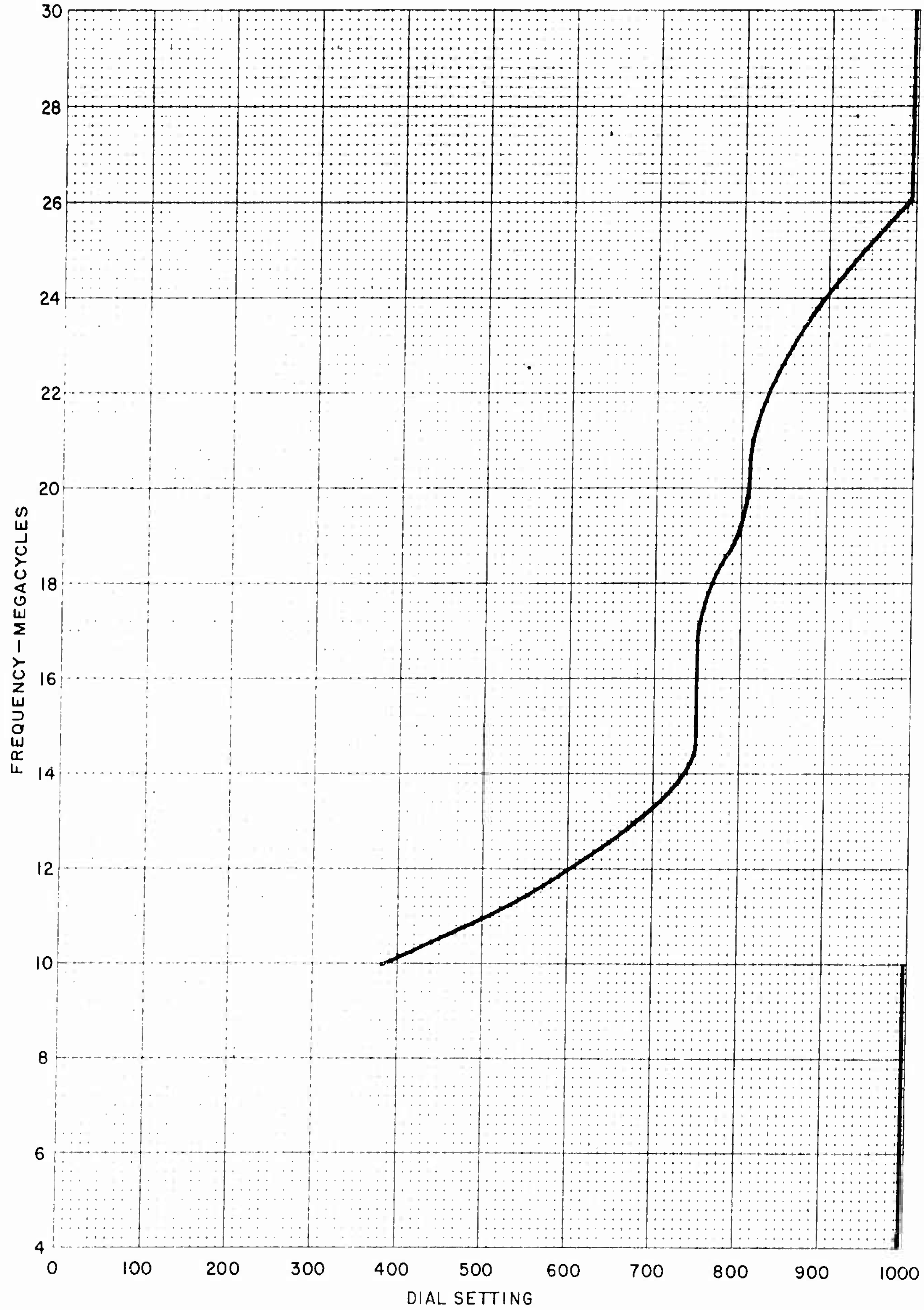


Figure 16. Tuning Chart, PI CAPACITOR Servo Control.

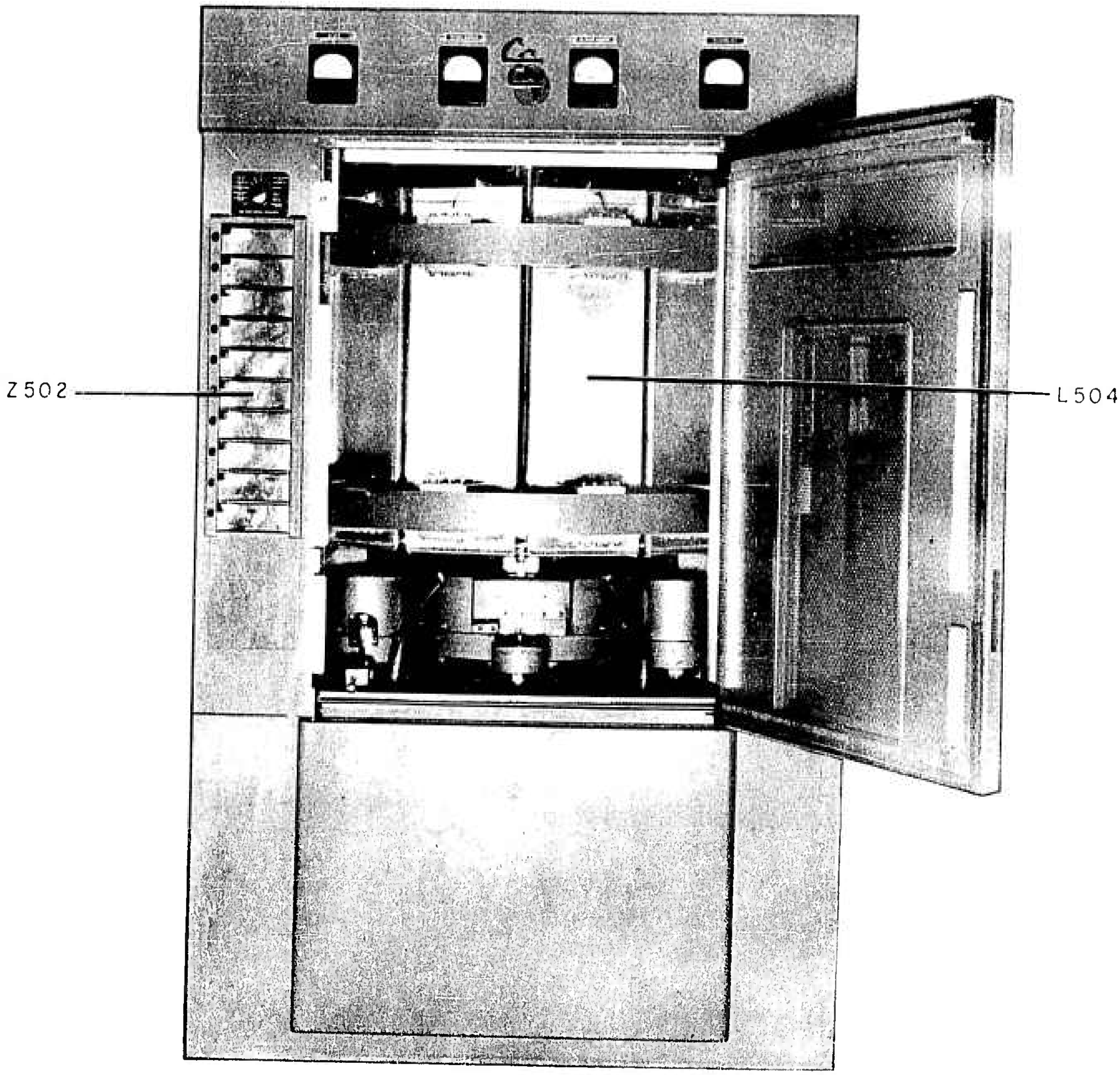
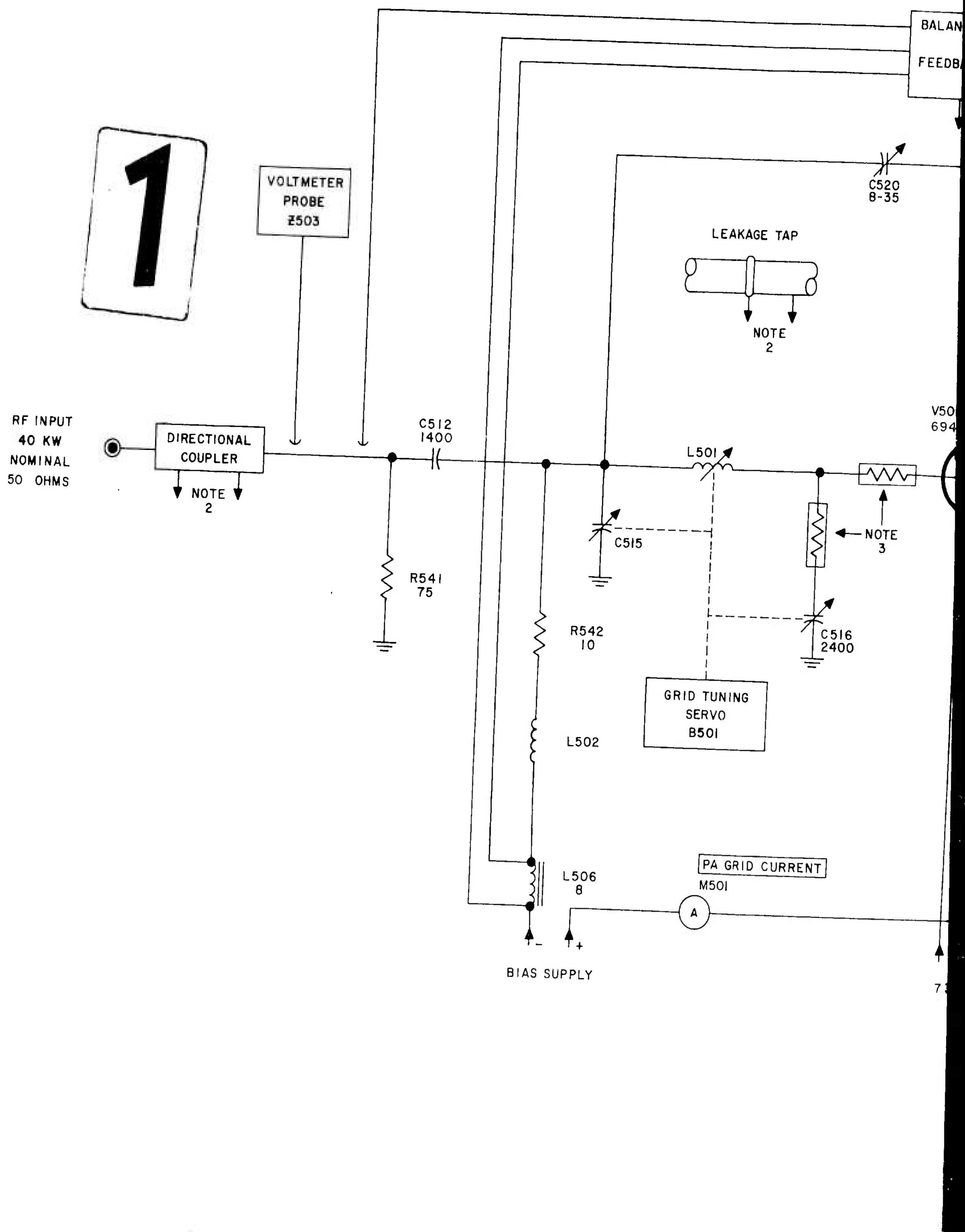
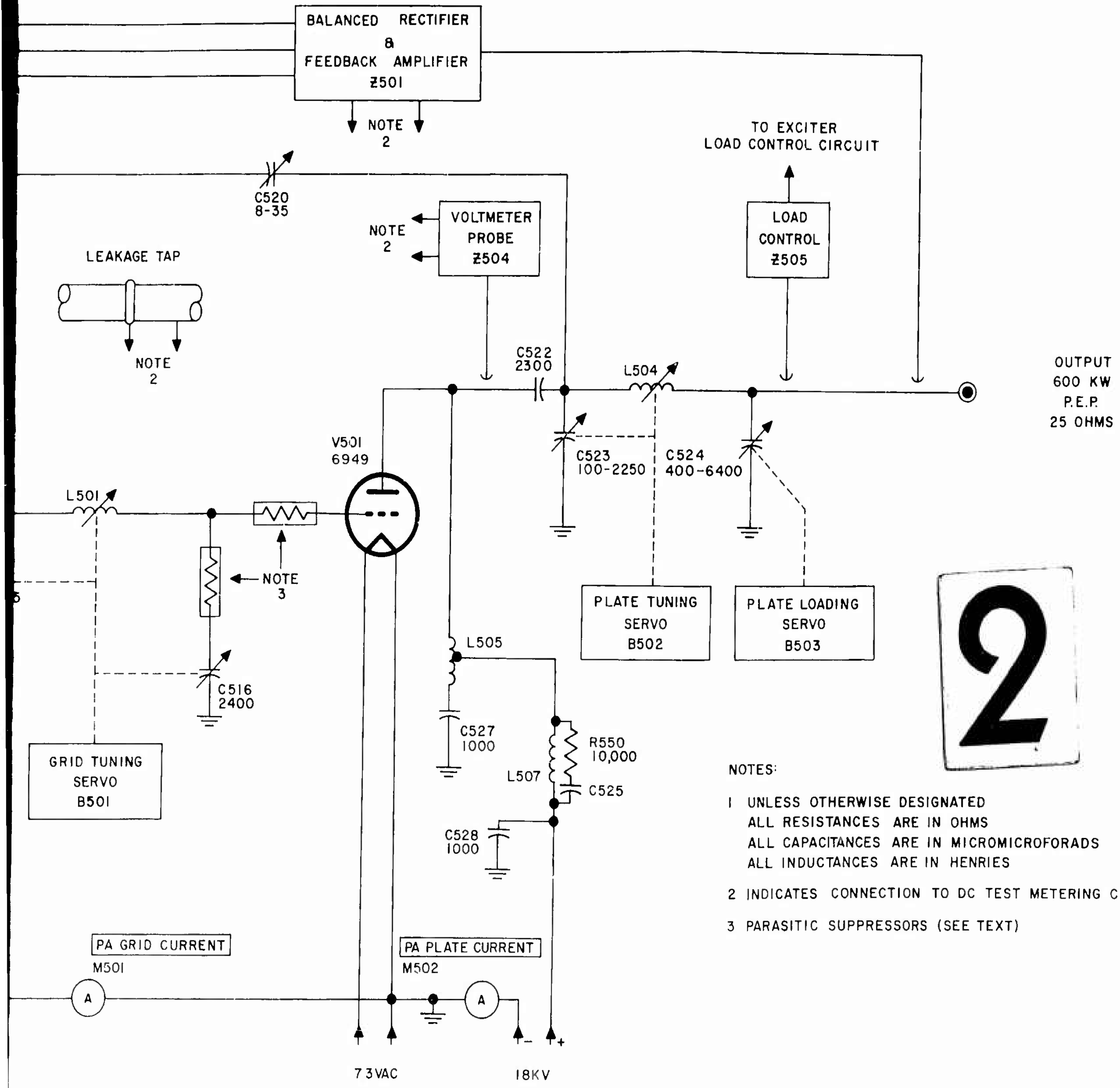


Figure 17. RF Amplifier Unit, Front View, Door Open.



1
VOLTMETER PROBE Z503
BALAN
FEEDB
C520 8-35
LEAKAGE TAP
NOTE 2
RF INPUT 40 KW NOMINAL 50 OHMS
DIRECTIONAL COUPLER
NOTE 2
C512 1400
L501
V50
694
NOTE 3
C515
R541 75
R542 10
C516 2400
GRID TUNING SERVO B501
L502
L506 8
PA GRID CURRENT
M501
A
BIAS SUPPLY



NOTES:

1 UNLESS OTHERWISE DESIGNATED
ALL RESISTANCES ARE IN OHMS
ALL CAPACITANCES ARE IN MICROMICROFORADS
ALL INDUCTANCES ARE IN HENRIES

2 INDICATES CONNECTION TO DC TEST METERING CIRCUIT

3 PARASITIC SUPPRESSORS (SEE TEXT)

Figure 18. Simplified Schematic Diagram, RF Amplifier.

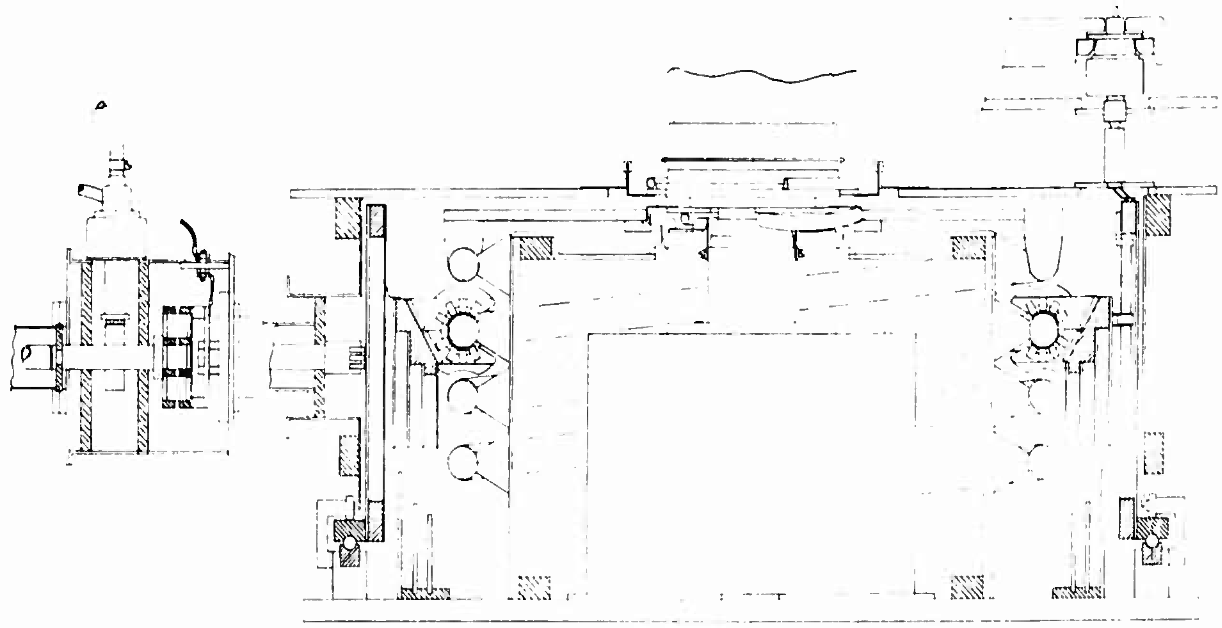


Figure 19. Cross-Section Diagram, Power Amplifier Input Circuit.

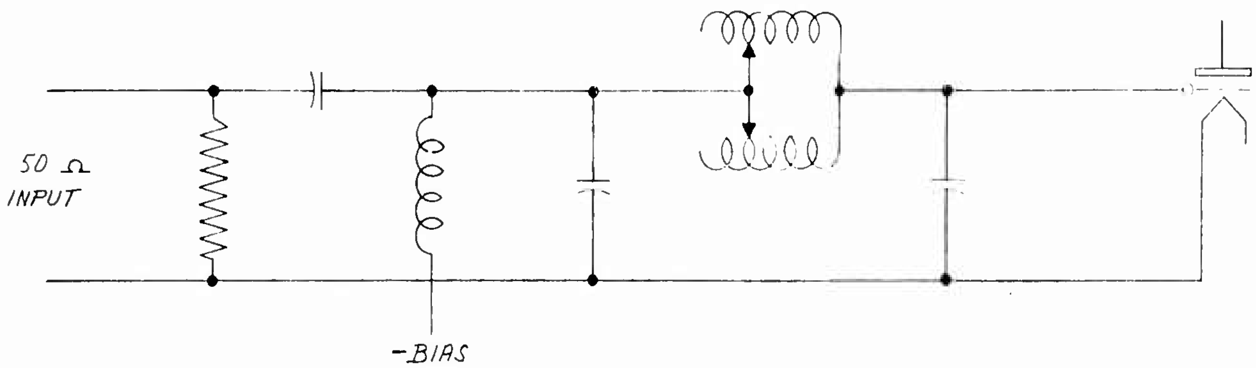


Figure 20. Simplified Schematic Diagram, Power Amplifier Input Circuit.

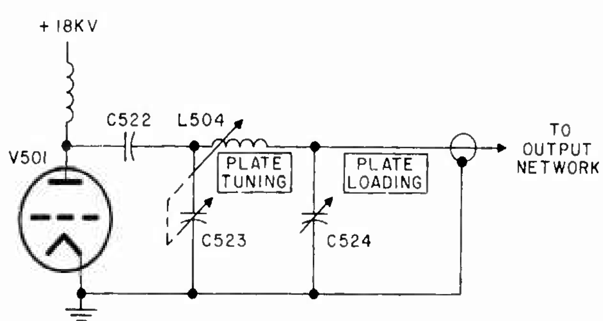


Figure 21. Simplified Schematic Diagram, Power Amplifier Output Circuit.

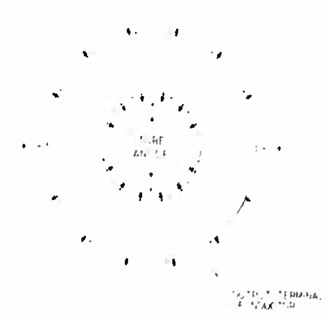


Figure 22. Simplified Diagram, Toroidal Plate Tank Inductor, L504

Figure 23. Power Amplifier Tube V501.

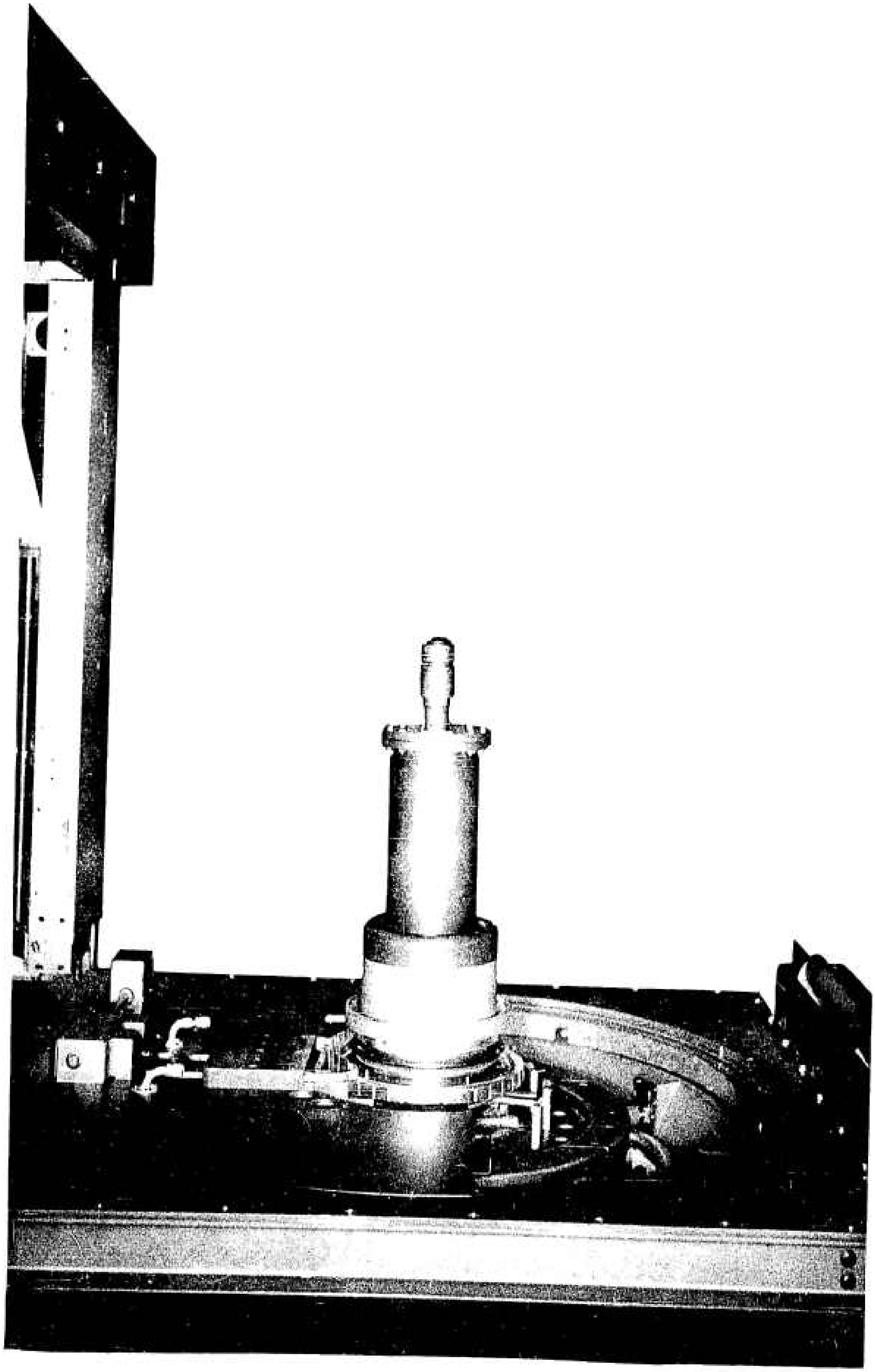


Figure 24. Power Amplifier Tube V501 in its Socket in the Grid Drawer.

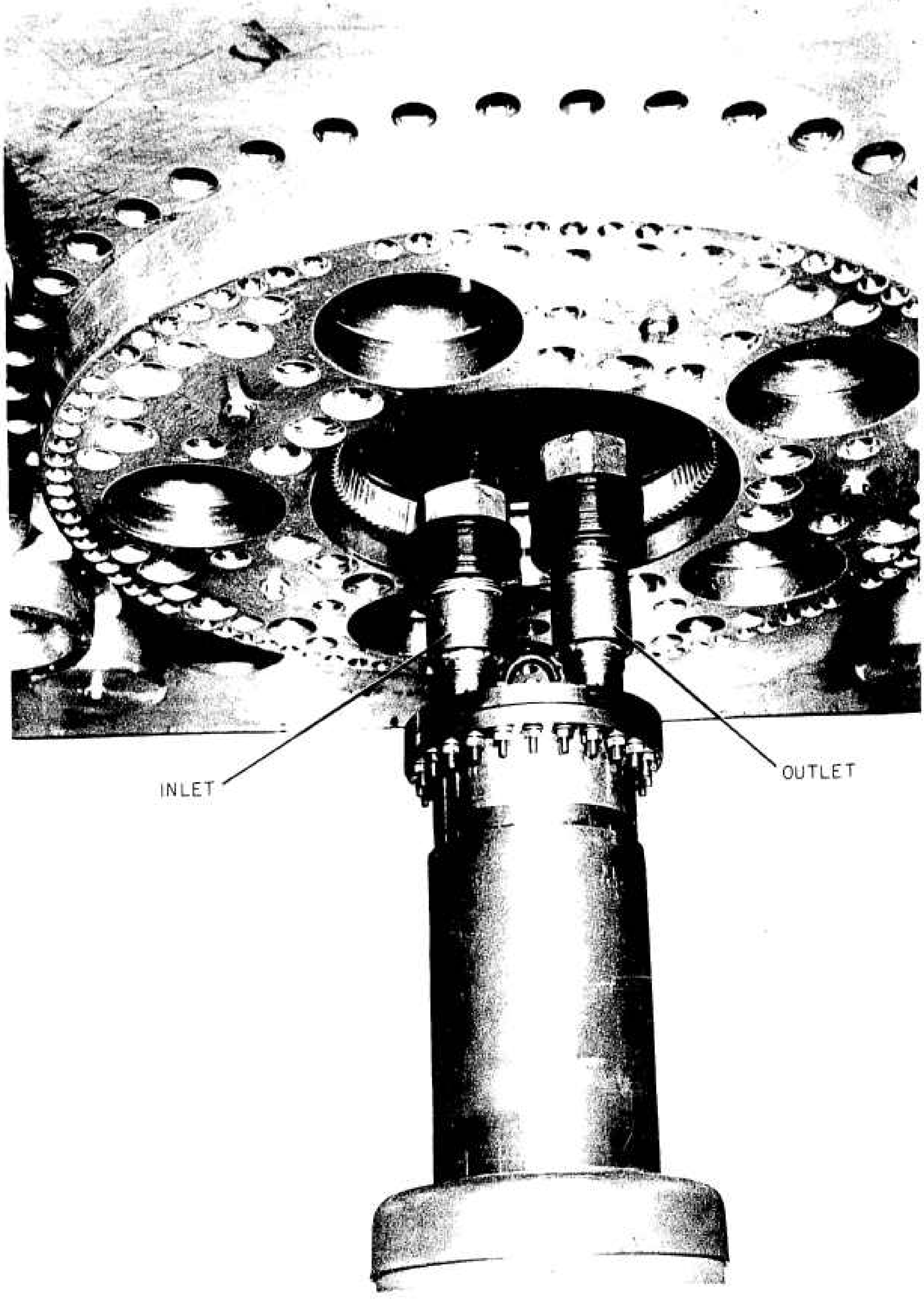


Figure 25. Power Amplifier Tube Water Fittings.

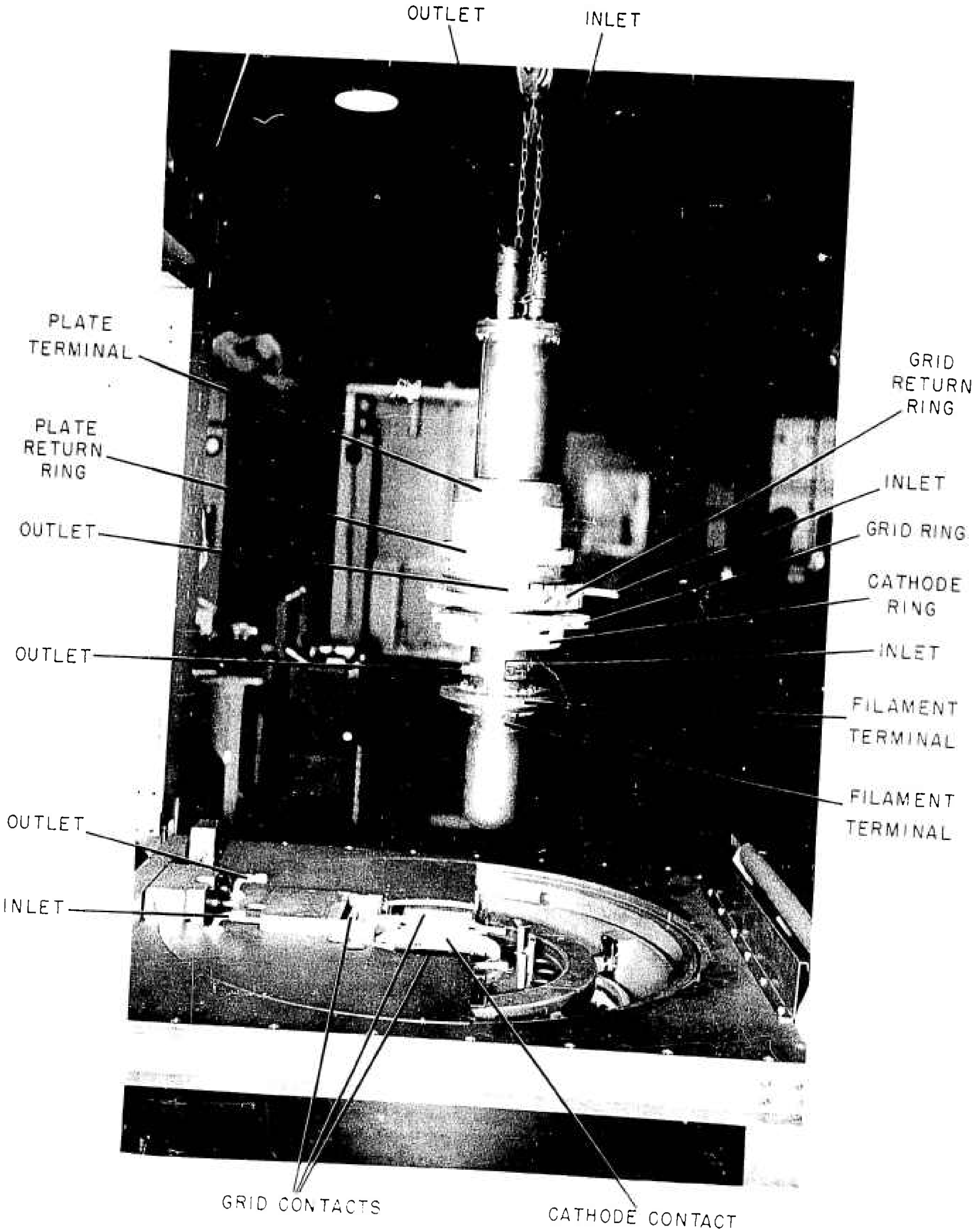


Figure 26. Power Amplifier Tube V501 with Dressing Installed.

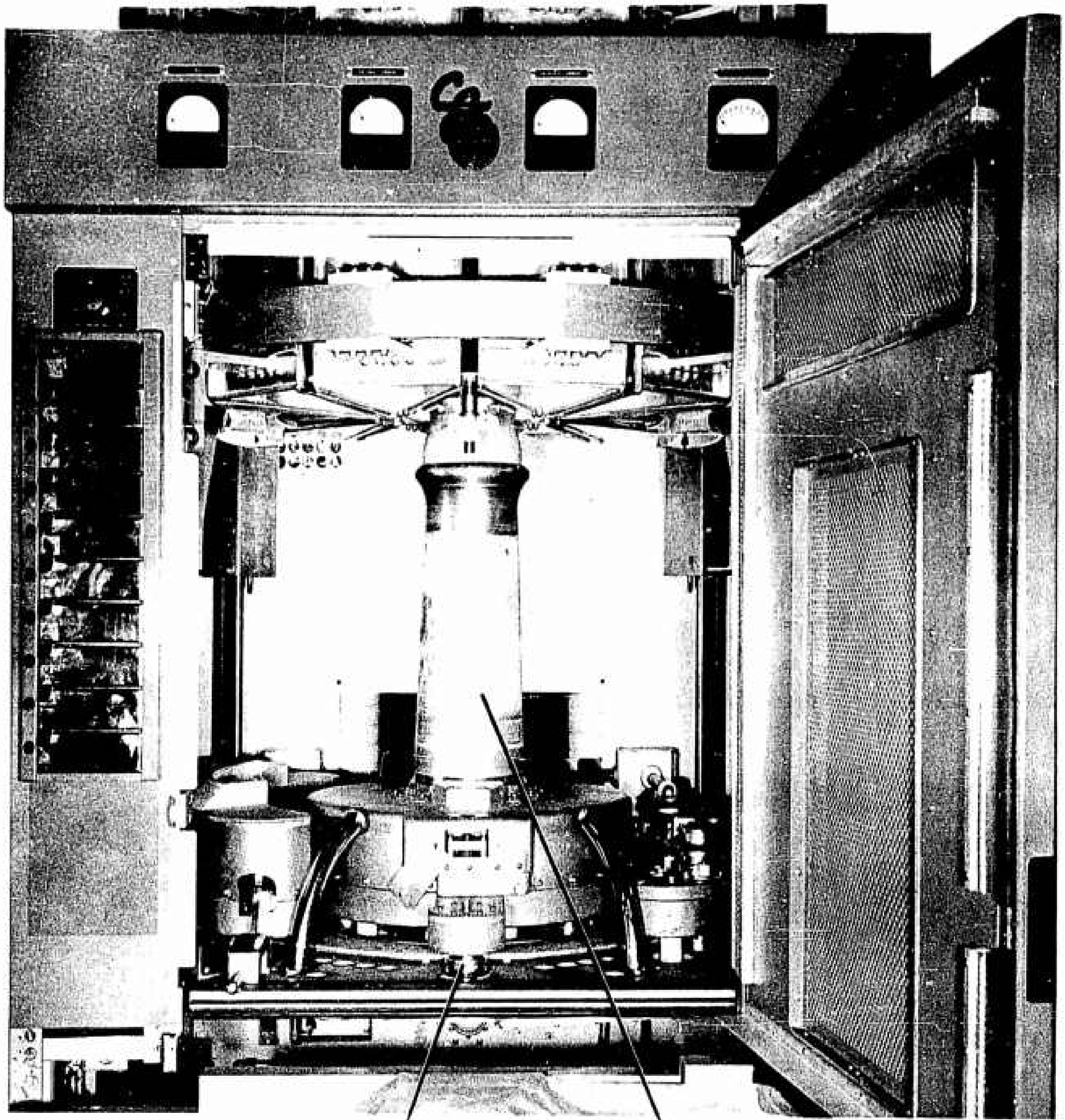


Figure 27. RF Amplifier Unit, Front View, Door Open, Grid Drawer Out, Plate Shelf Separated.

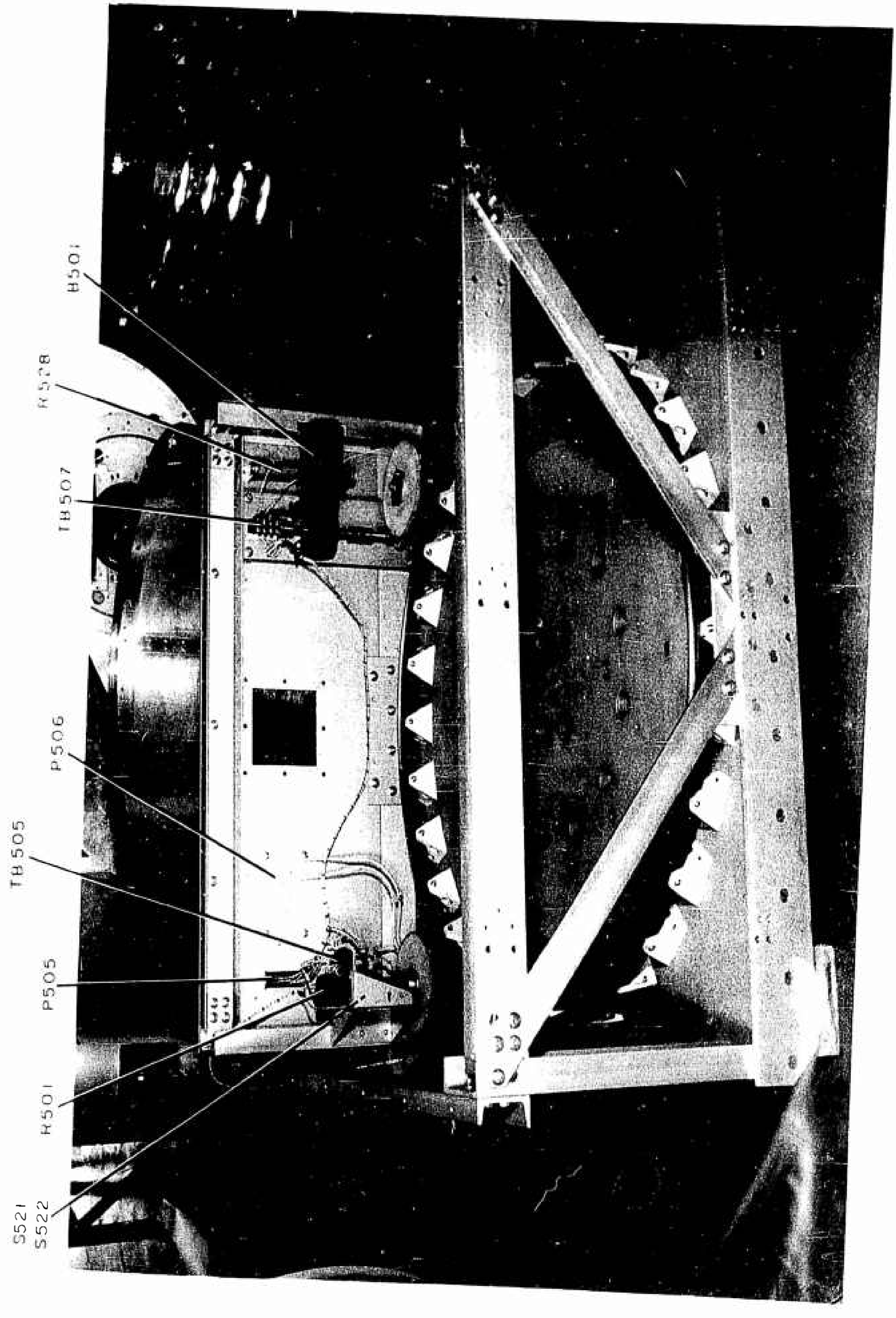


Figure 28. Grid Drawer, Disassembled, Showing Grid Tuning Servo Drive System.

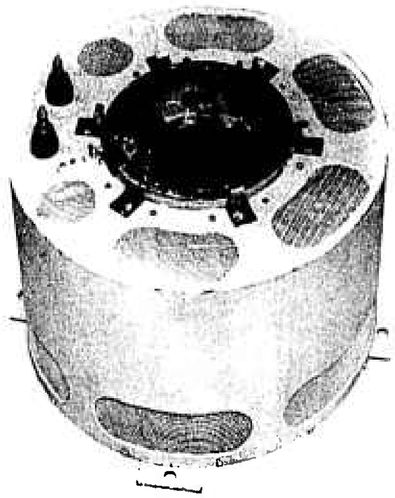


Figure 29. PA Filament Transformer T503.

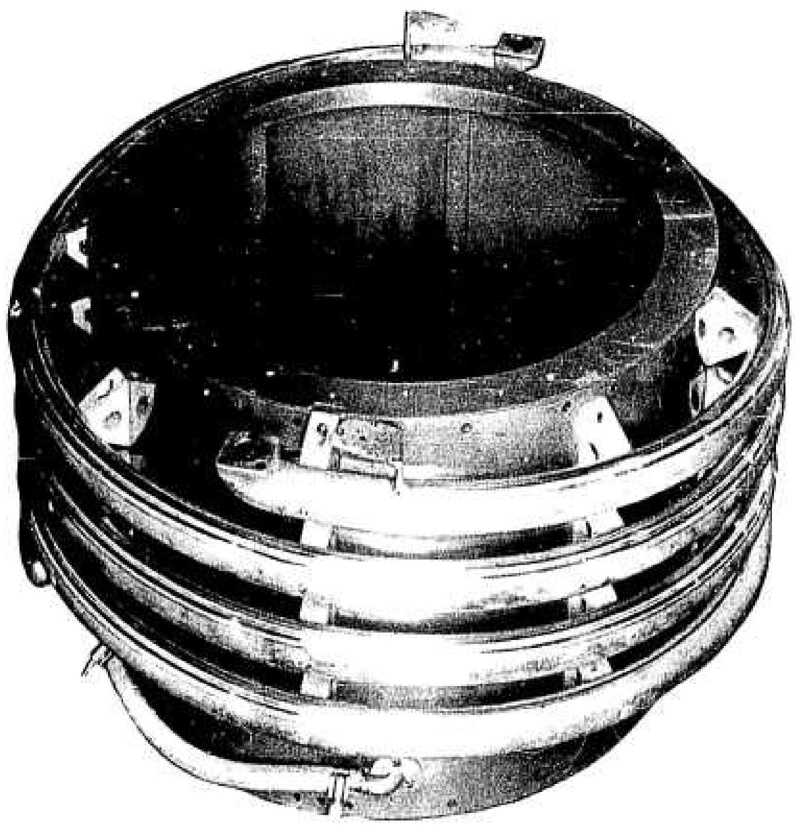


Figure 30. Grid Tuning Inductor L501.

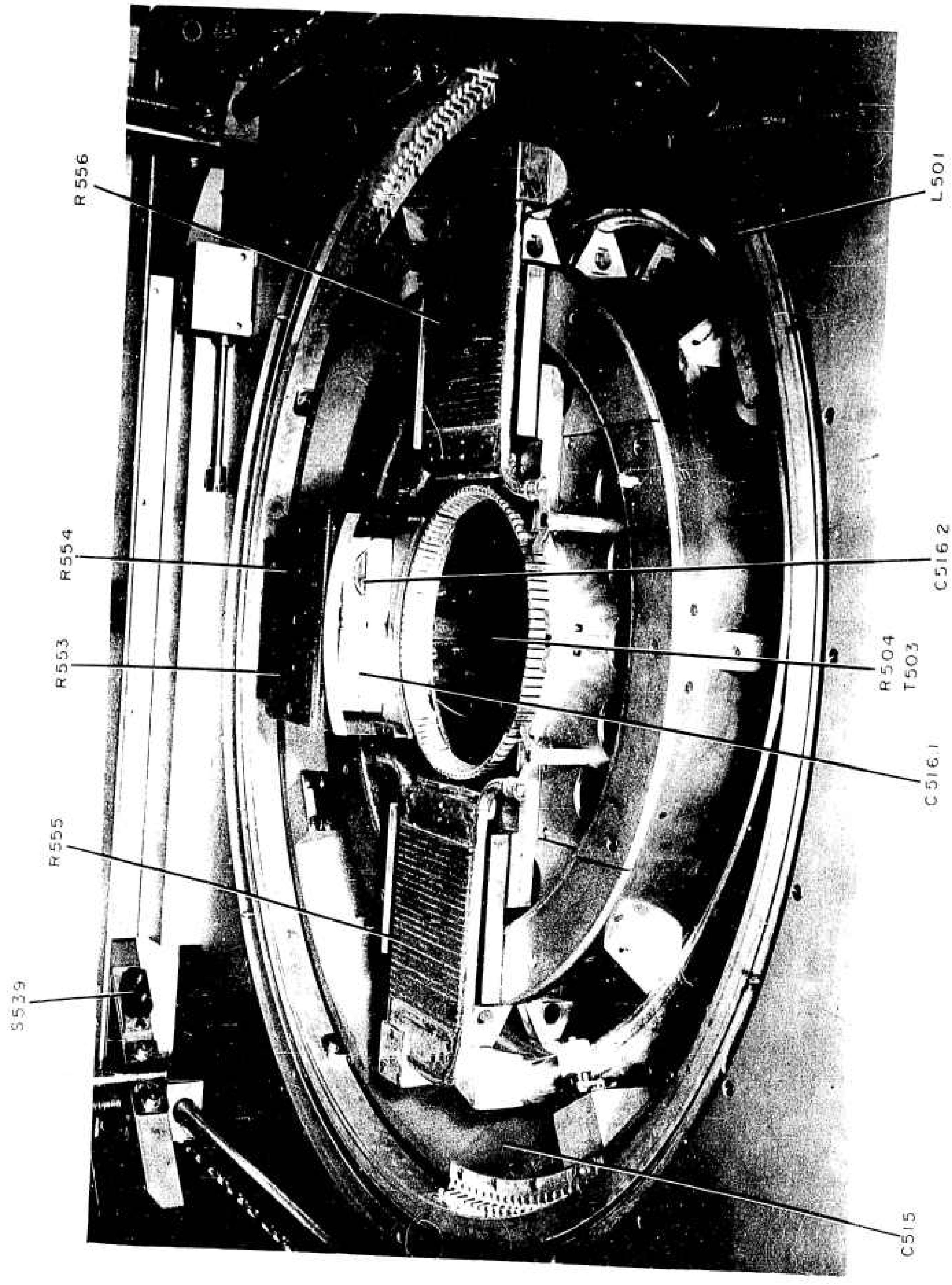


Figure 31. Grid Drawer, Cover Removed.

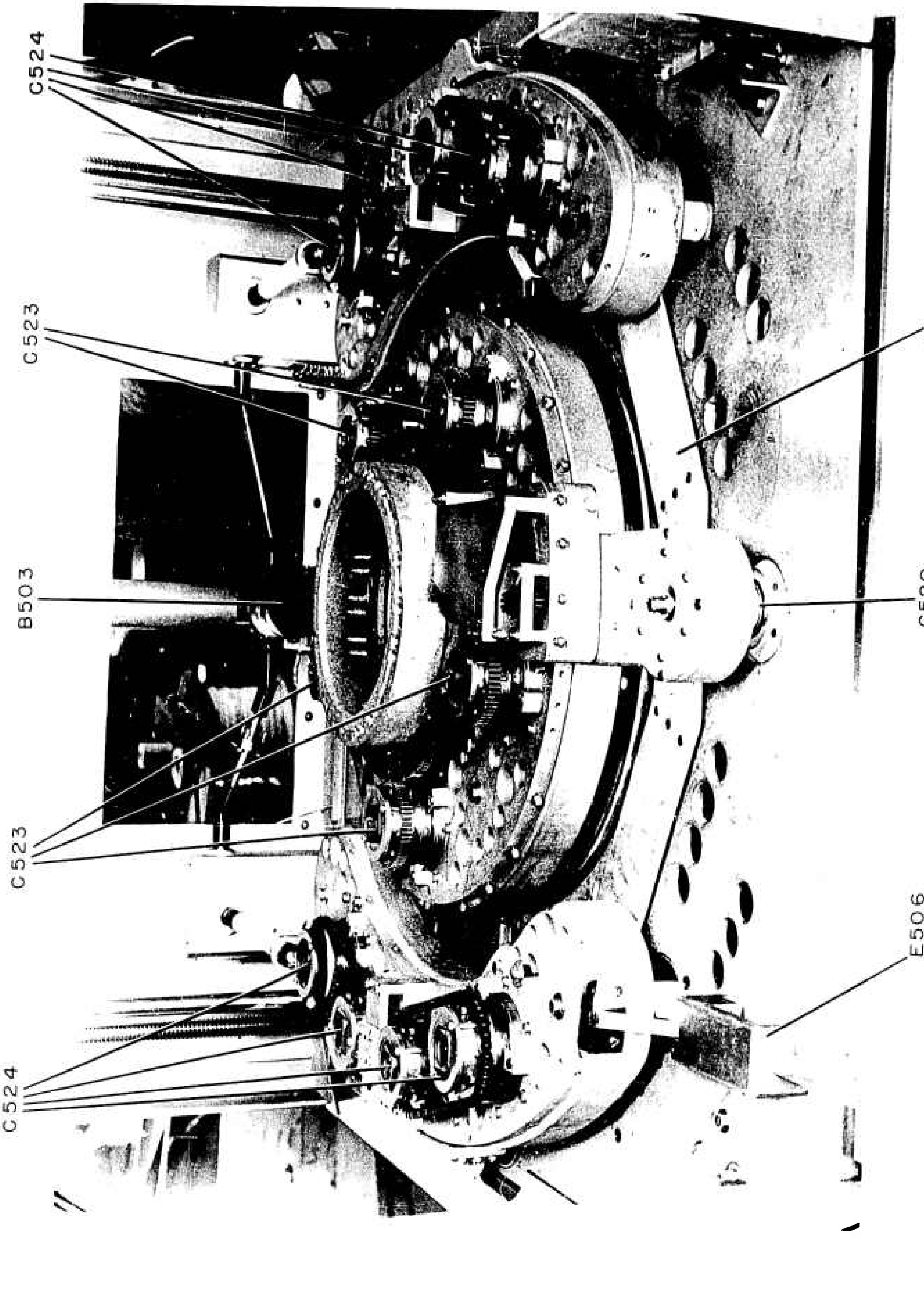


Figure 32. Lower Part of Plate Shelf, Front View, Capacitor Covers Removed.

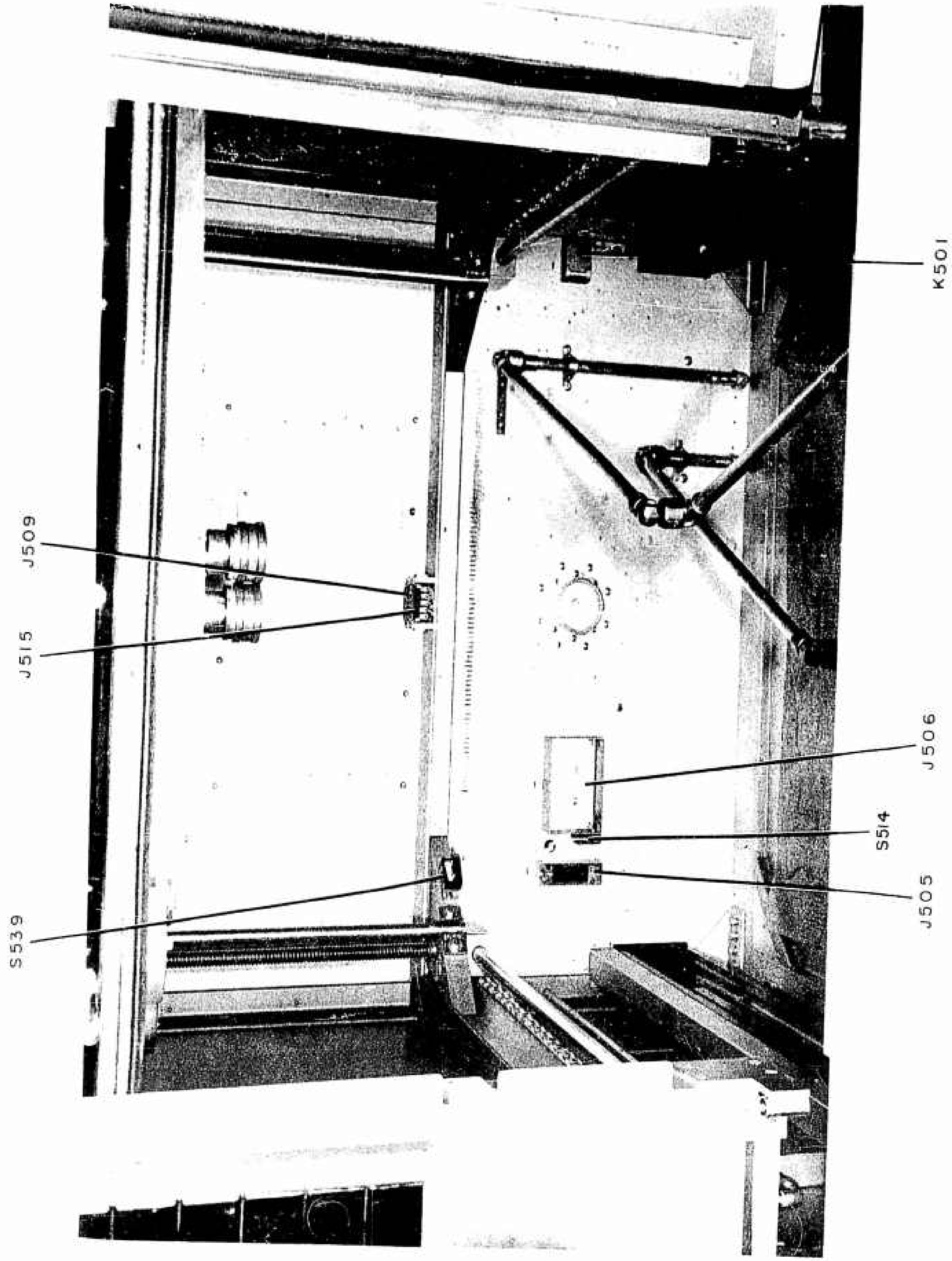


Figure 33. RF Amplifier Unit, Interior of Lower Front Compartment.

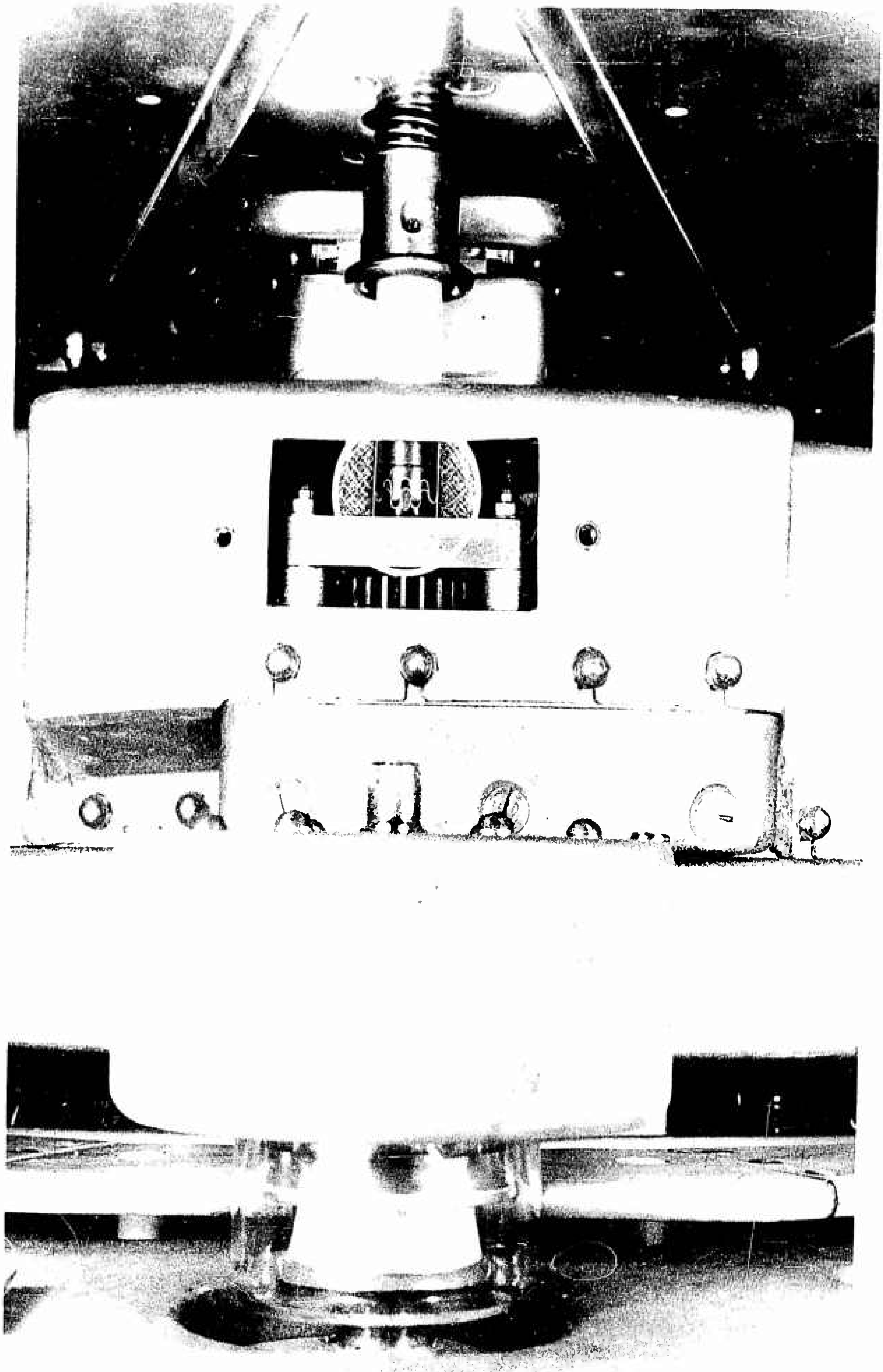


Figure 34. RF Amplifier Unit, Detail Showing Plate Tuning Capacitor Drive Coupling.

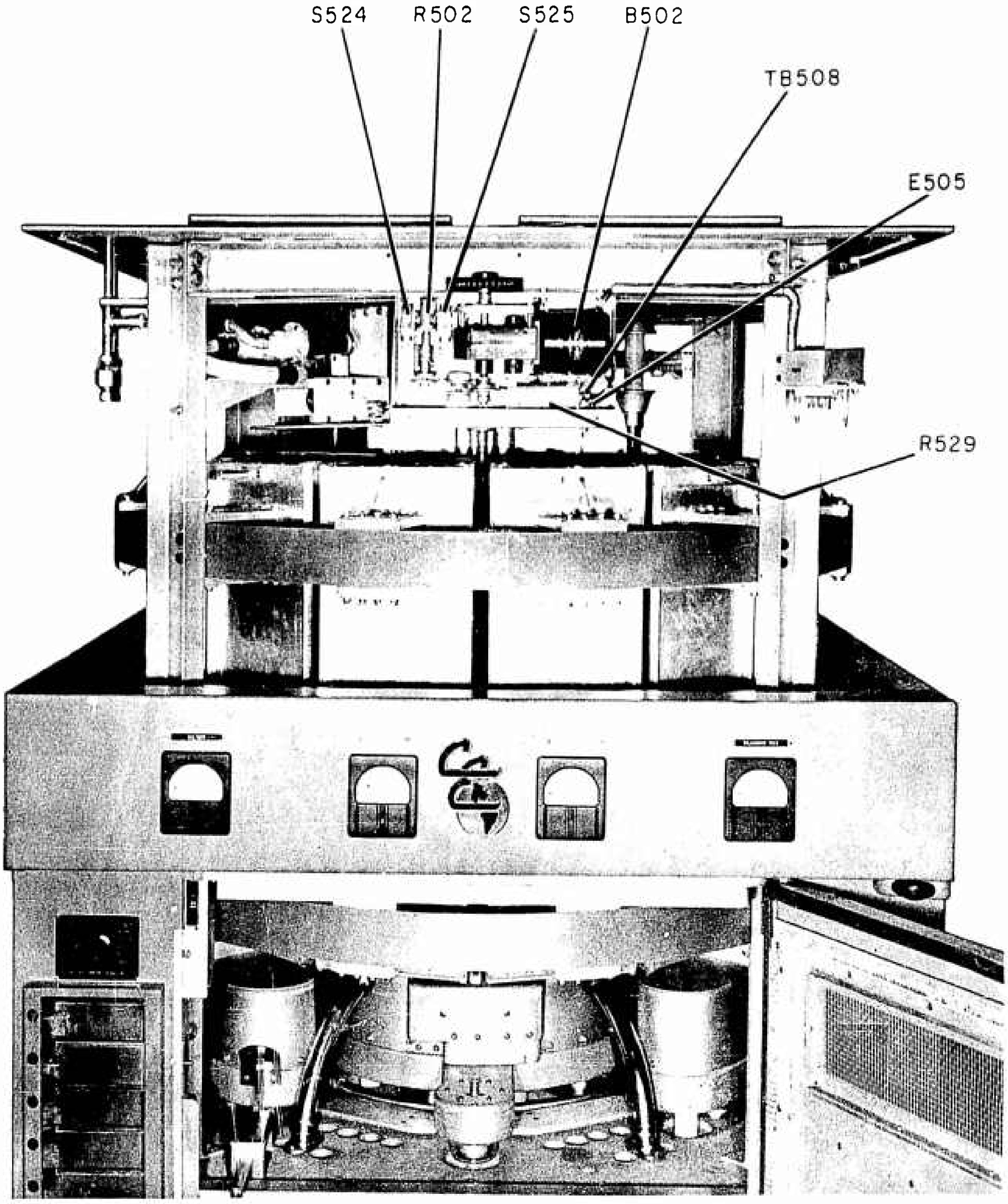


Figure 35. Plate Tuning Servo Drive Assembly.

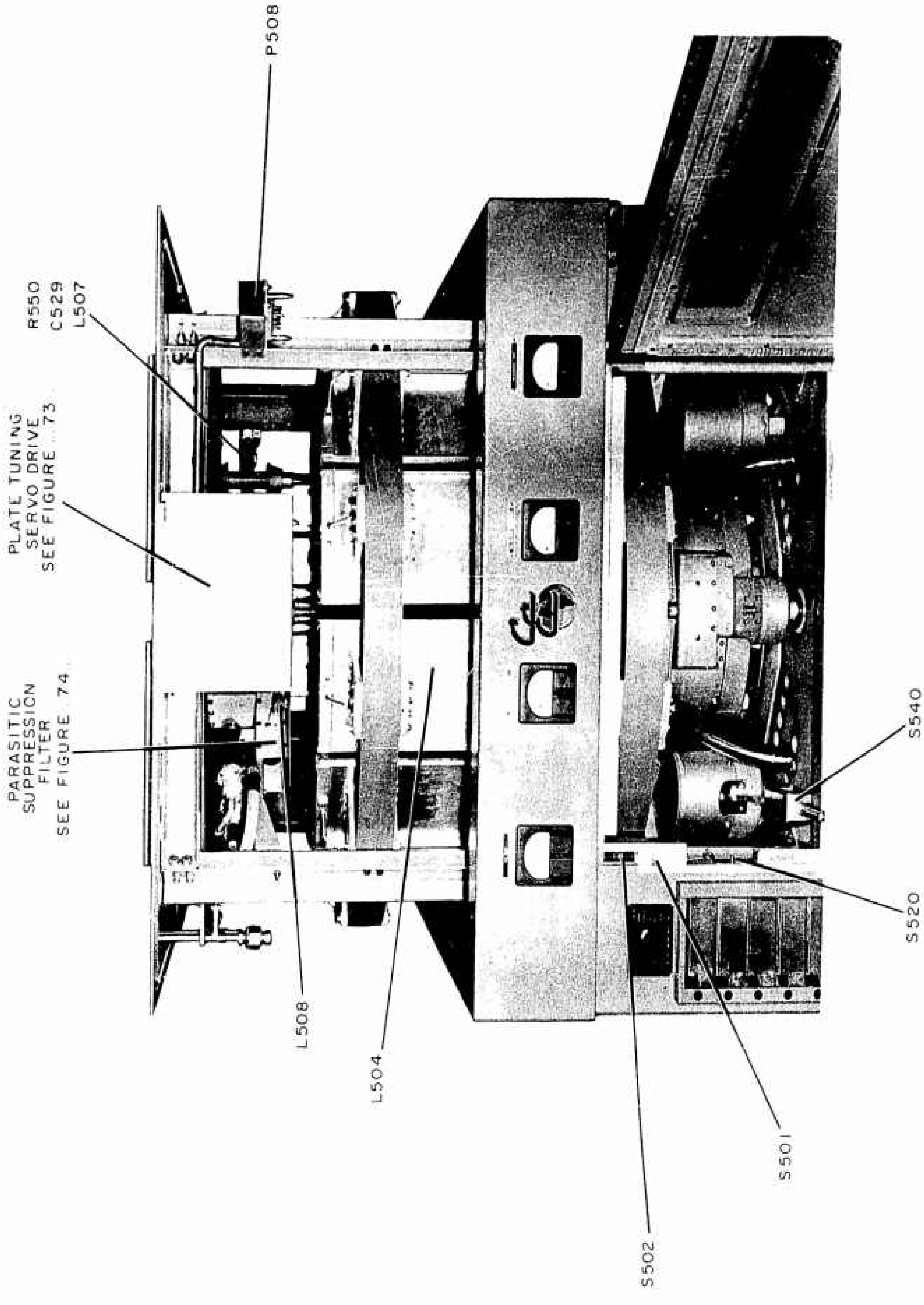


Figure 36. Plate Shelf, in Raised Position, Front View.

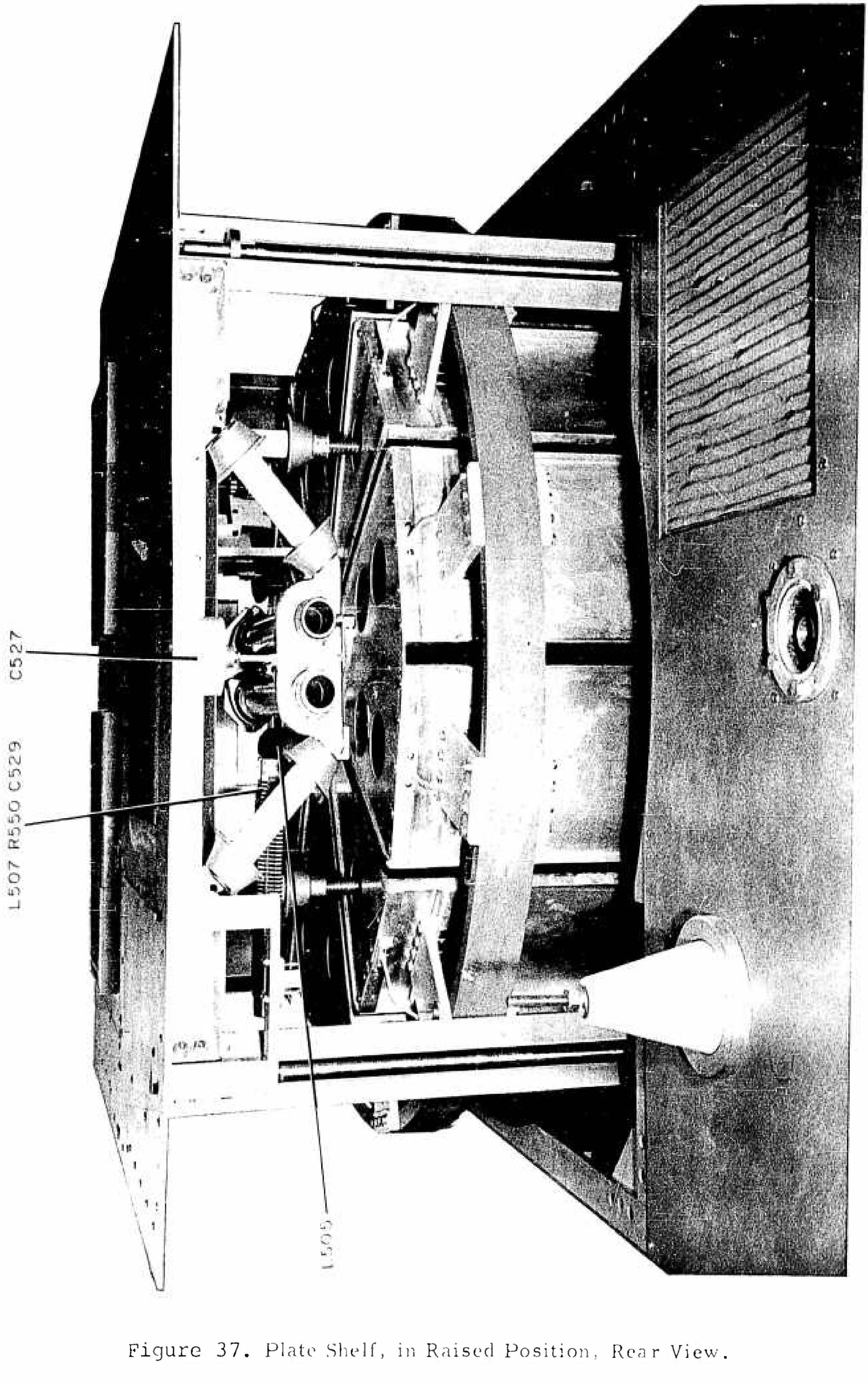


Figure 37. Plate Shelf, in Raised Position, Rear View.

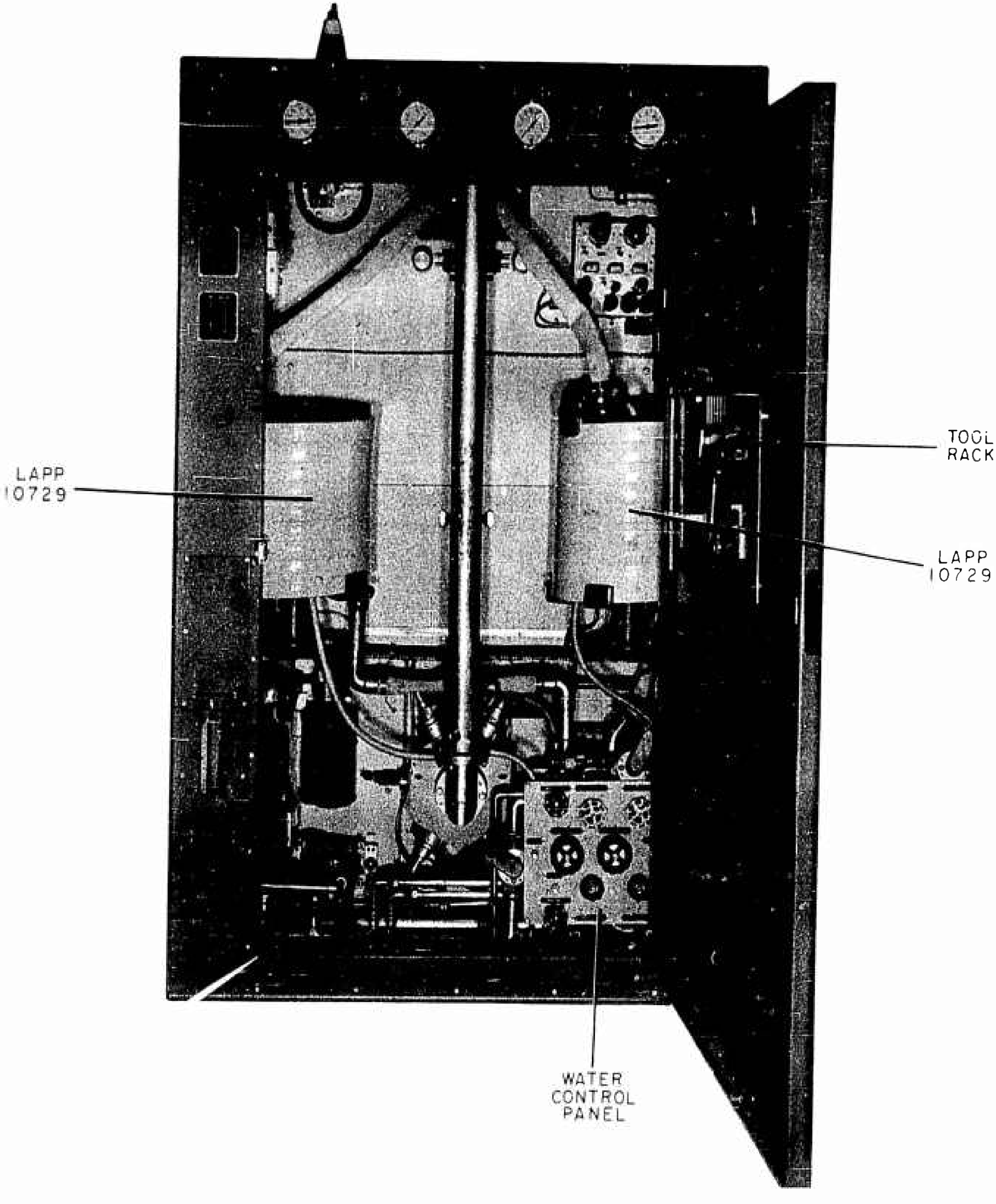


Figure 38. RF Amplifier Unit, Rear View, Door Open.

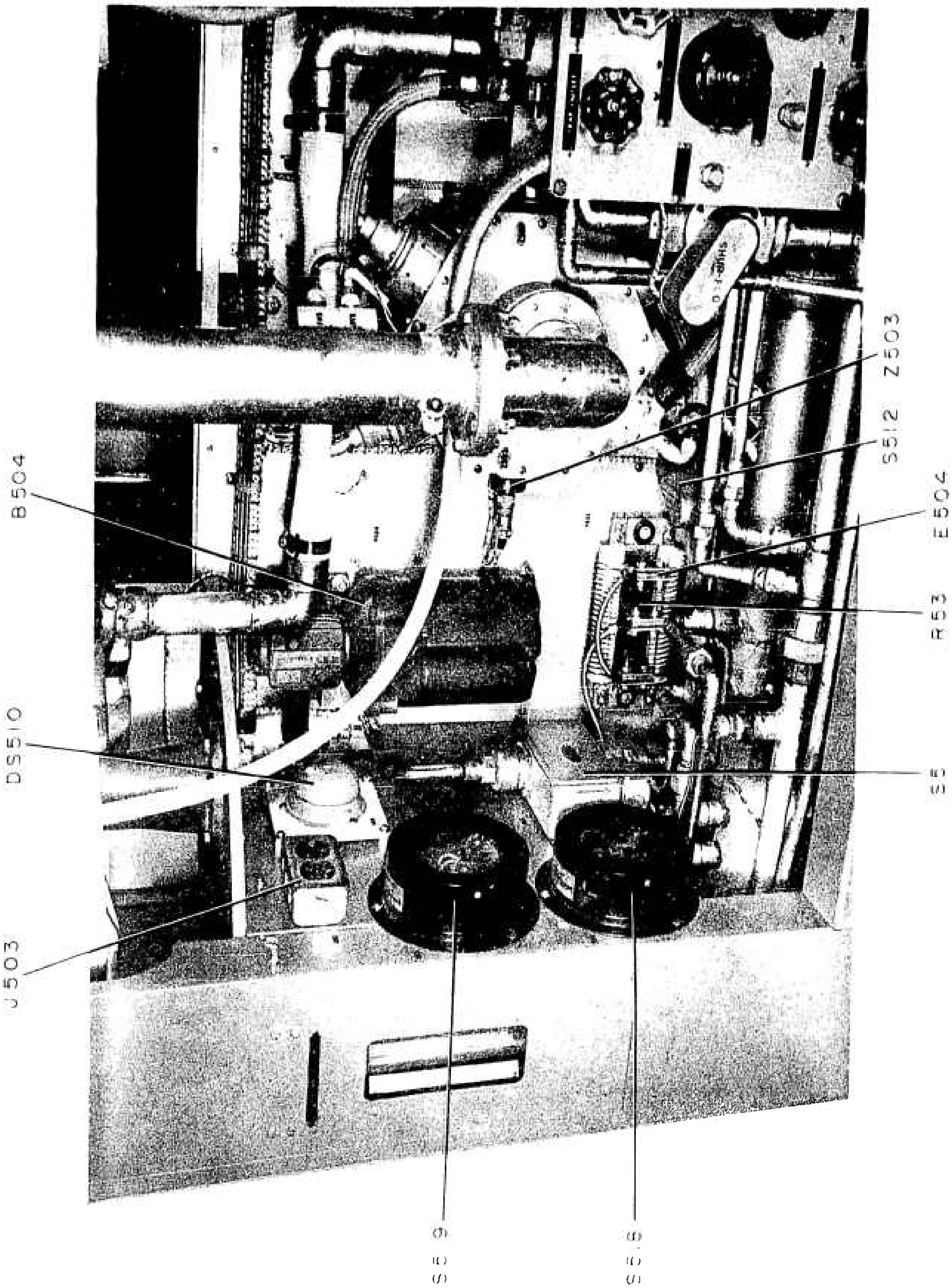


Figure 39. RF Amplifier Unit, Lower Left Portion of Rear Compartment.

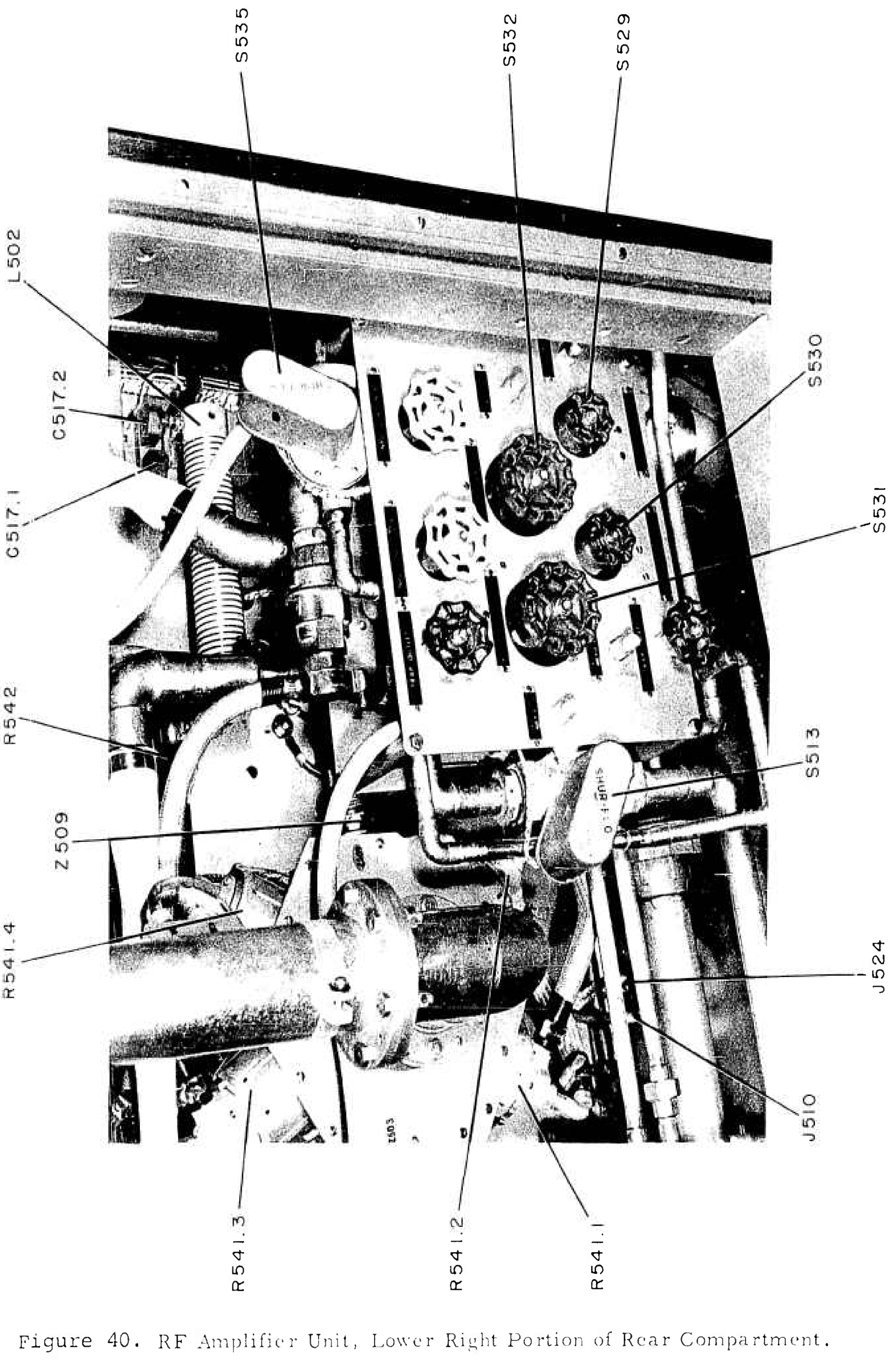


Figure 40. RF Amplifier Unit, Lower Right Portion of Rear Compartment.

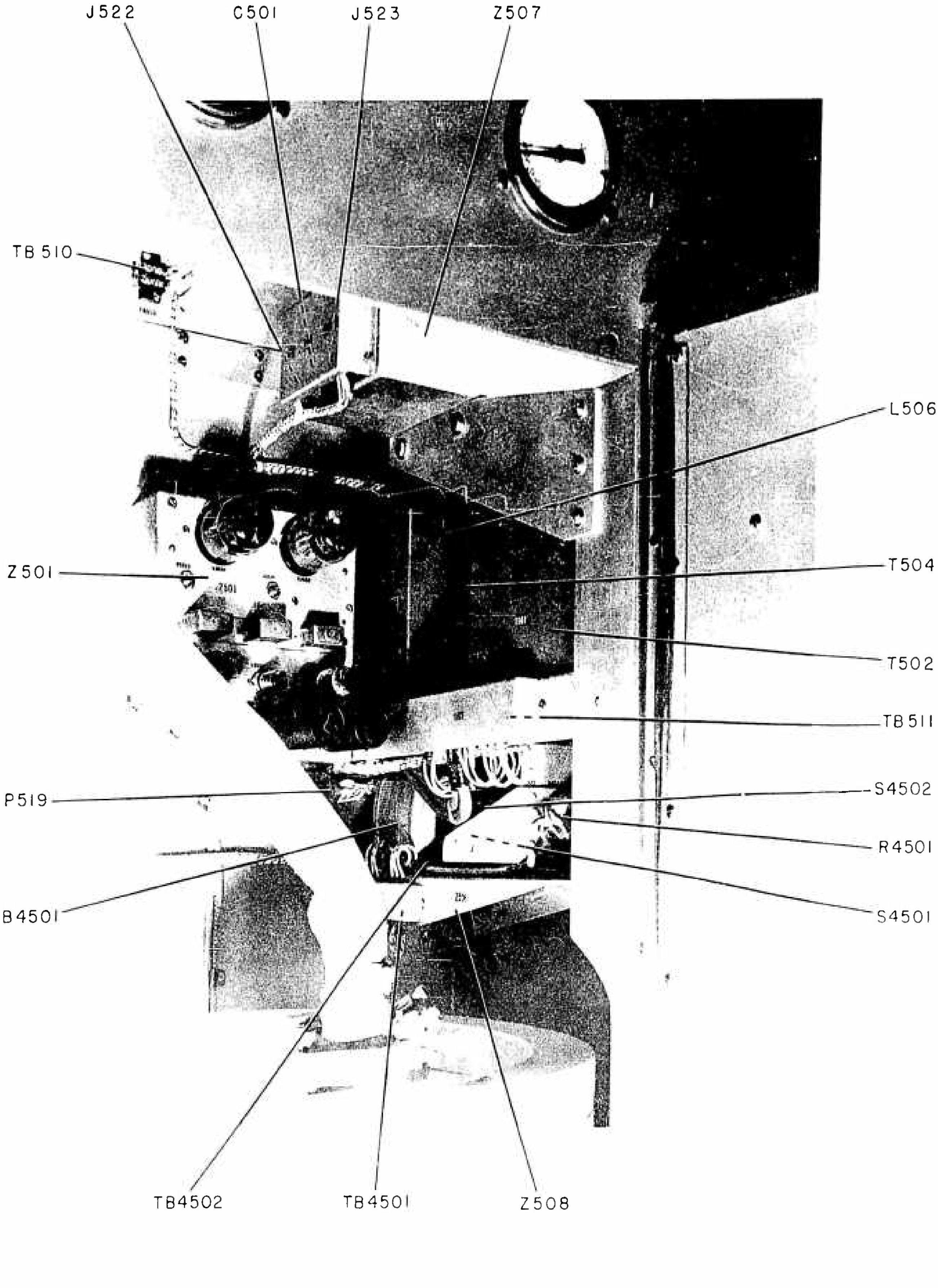


Figure 41. RF Amplifier Unit, Upper Right Portion of Rear Compartment.

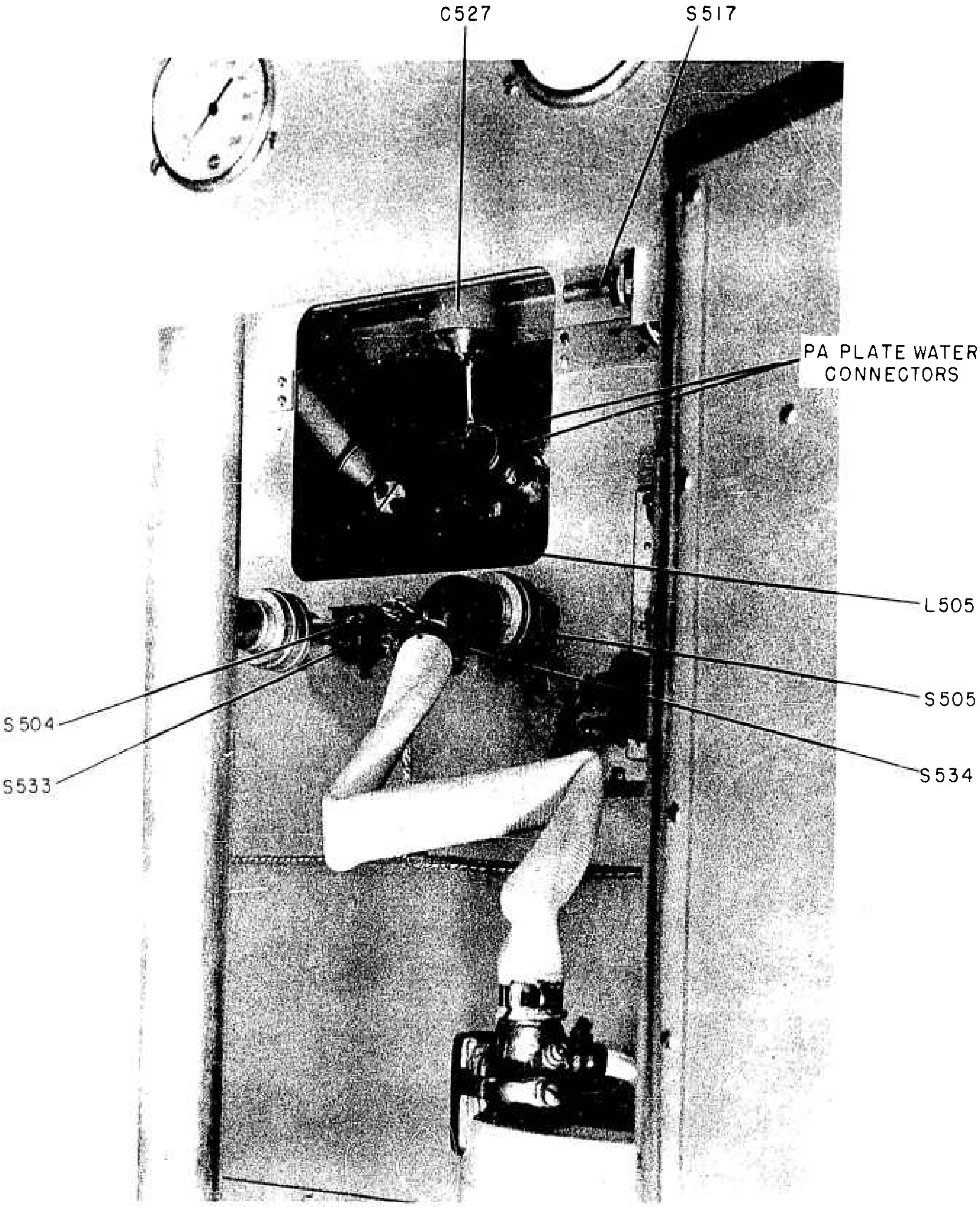


Figure 42. RF Amplifier Unit, Upper Center Portion of Rear Compartment.

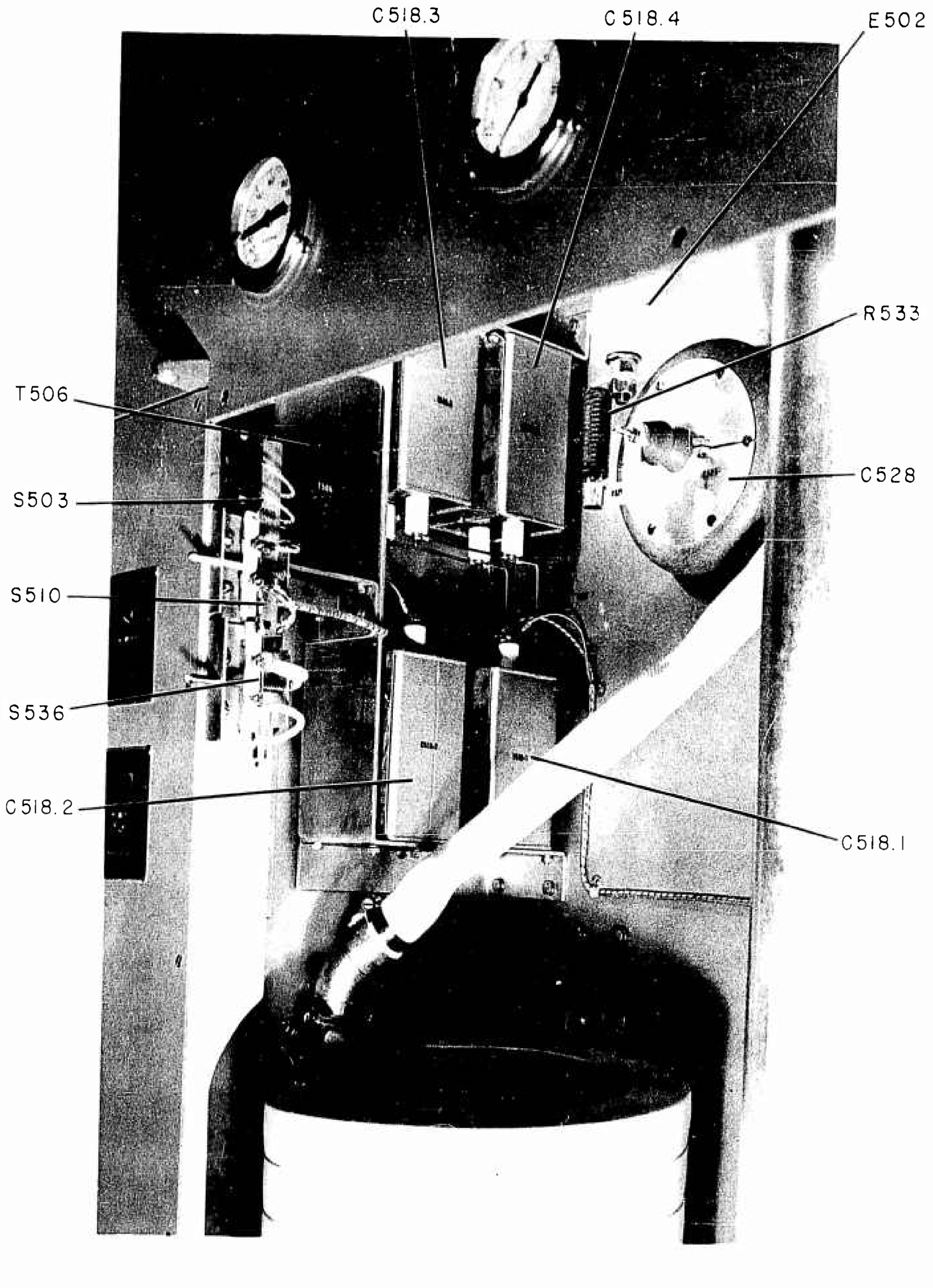


Figure 43. RF Amplifier Unit, Upper Left Portion of Rear Compartment.

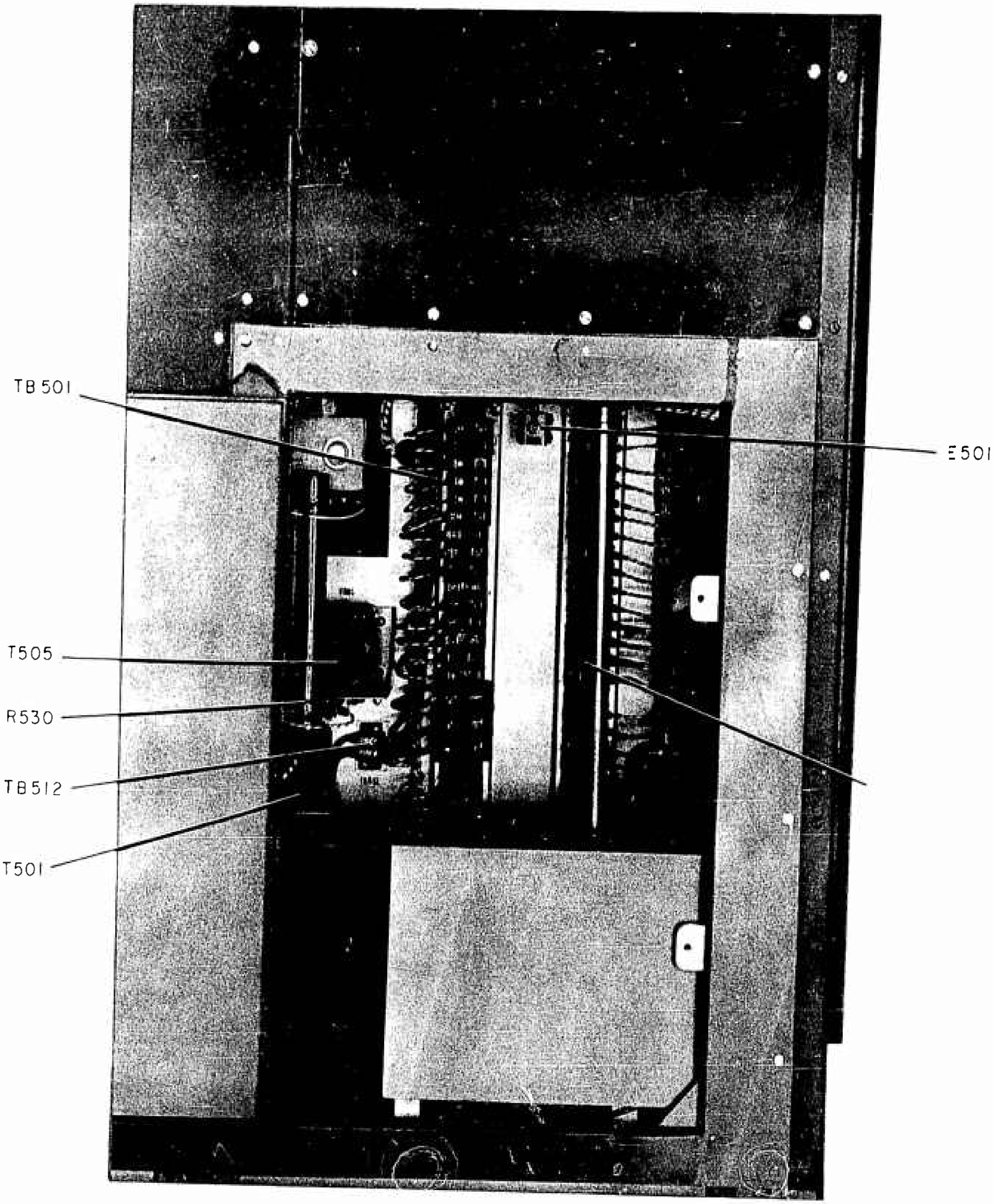


Figure 44. RF Amplifier Unit, Lower Side Panel, Access Cover Open.

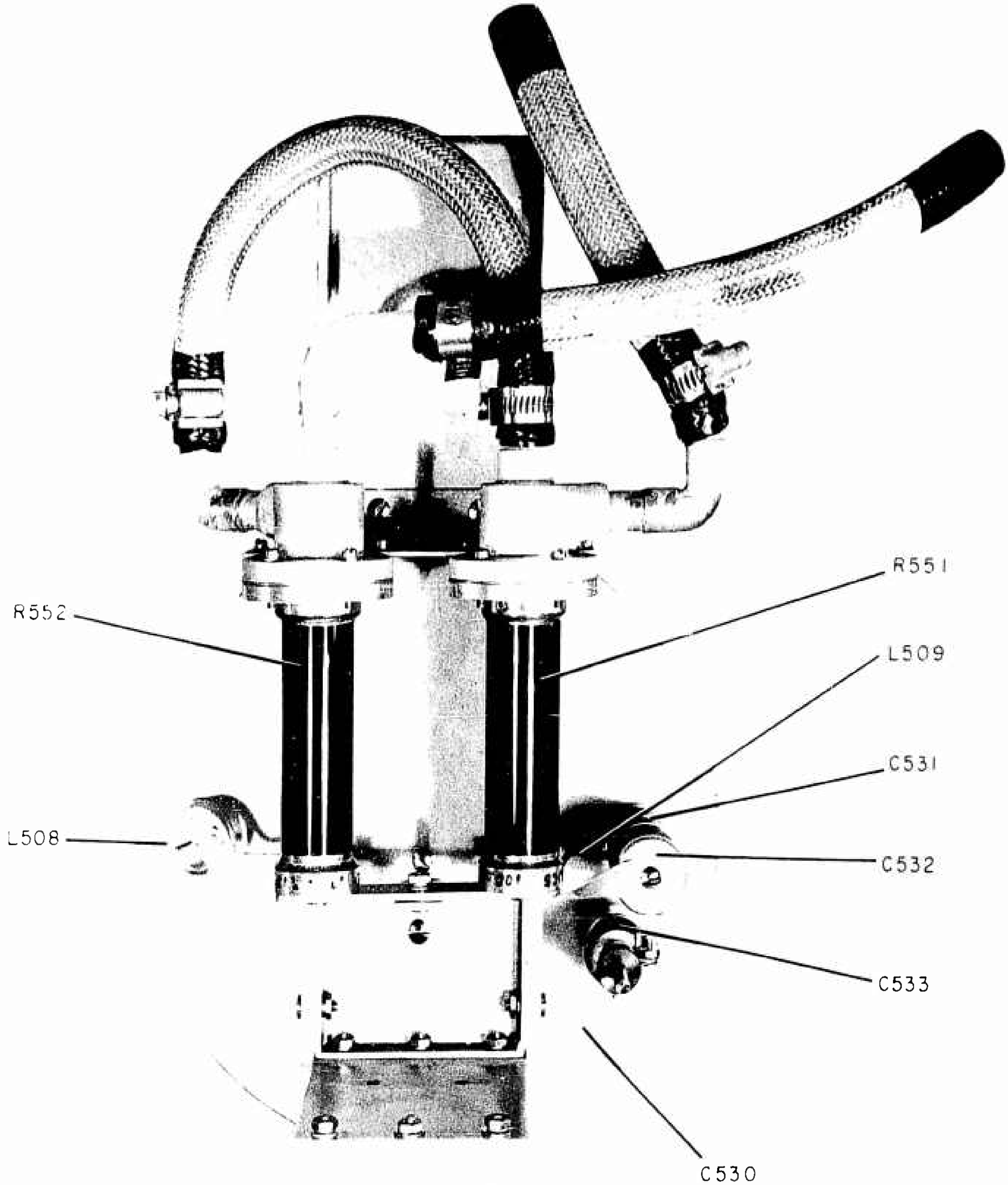


Figure 45. Plate Circuit Parasitic Suppression Filter.

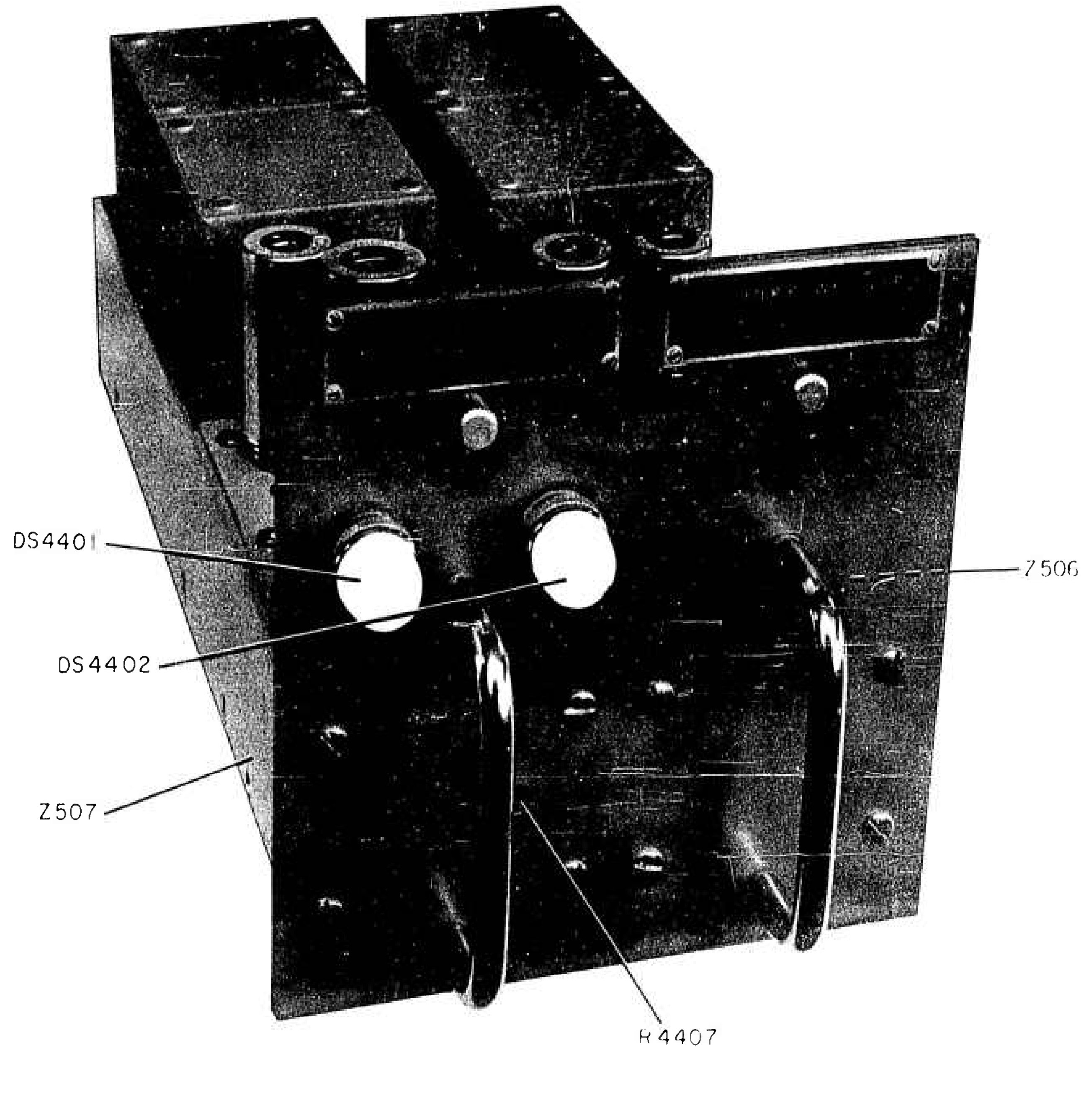


Figure 46. Servo Power Supply Z506 and Servo Amplifier Z507, Oblique View.

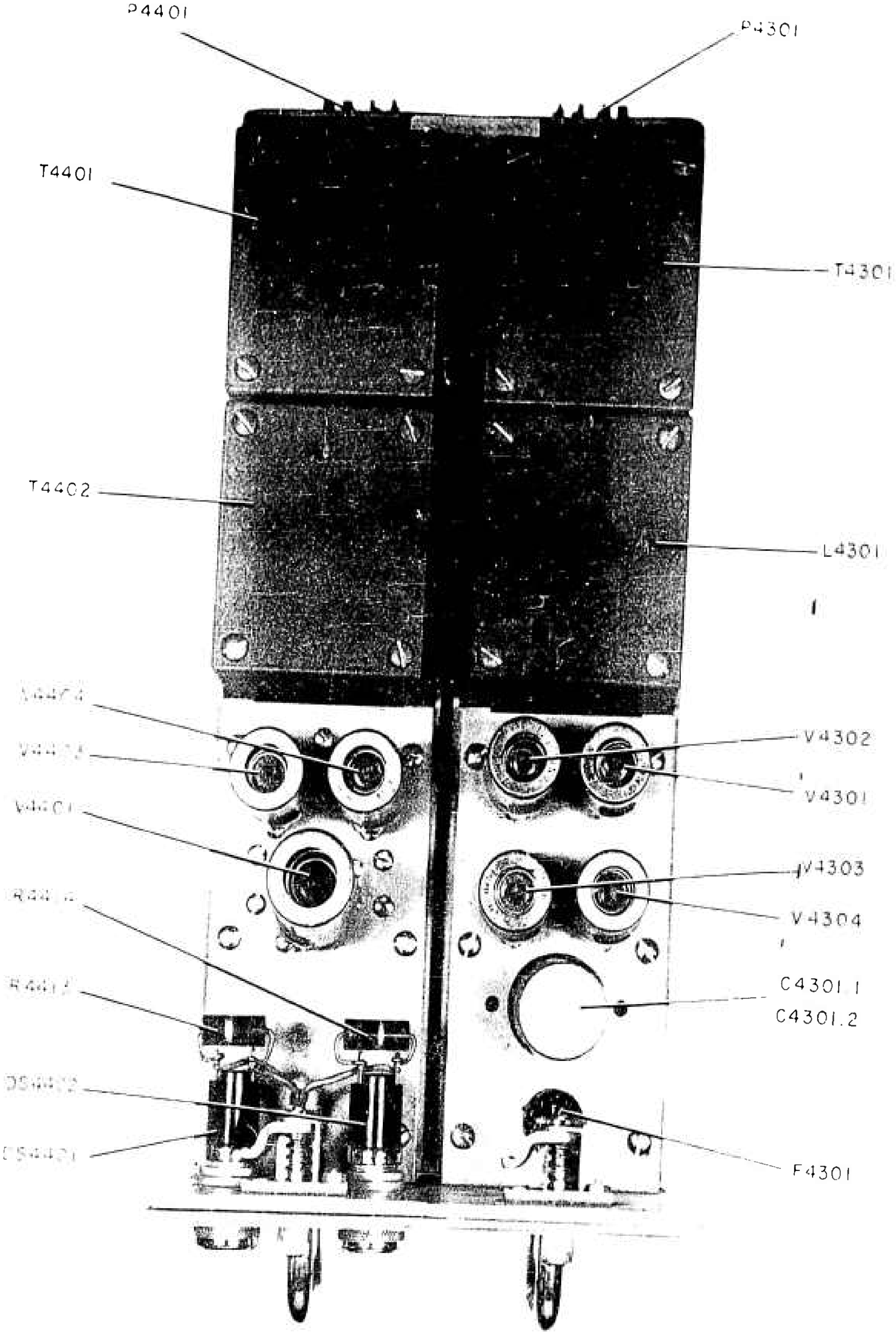


Figure 47. Servo Power Supply Z506 and Servo Amplifier Z507, Top View.

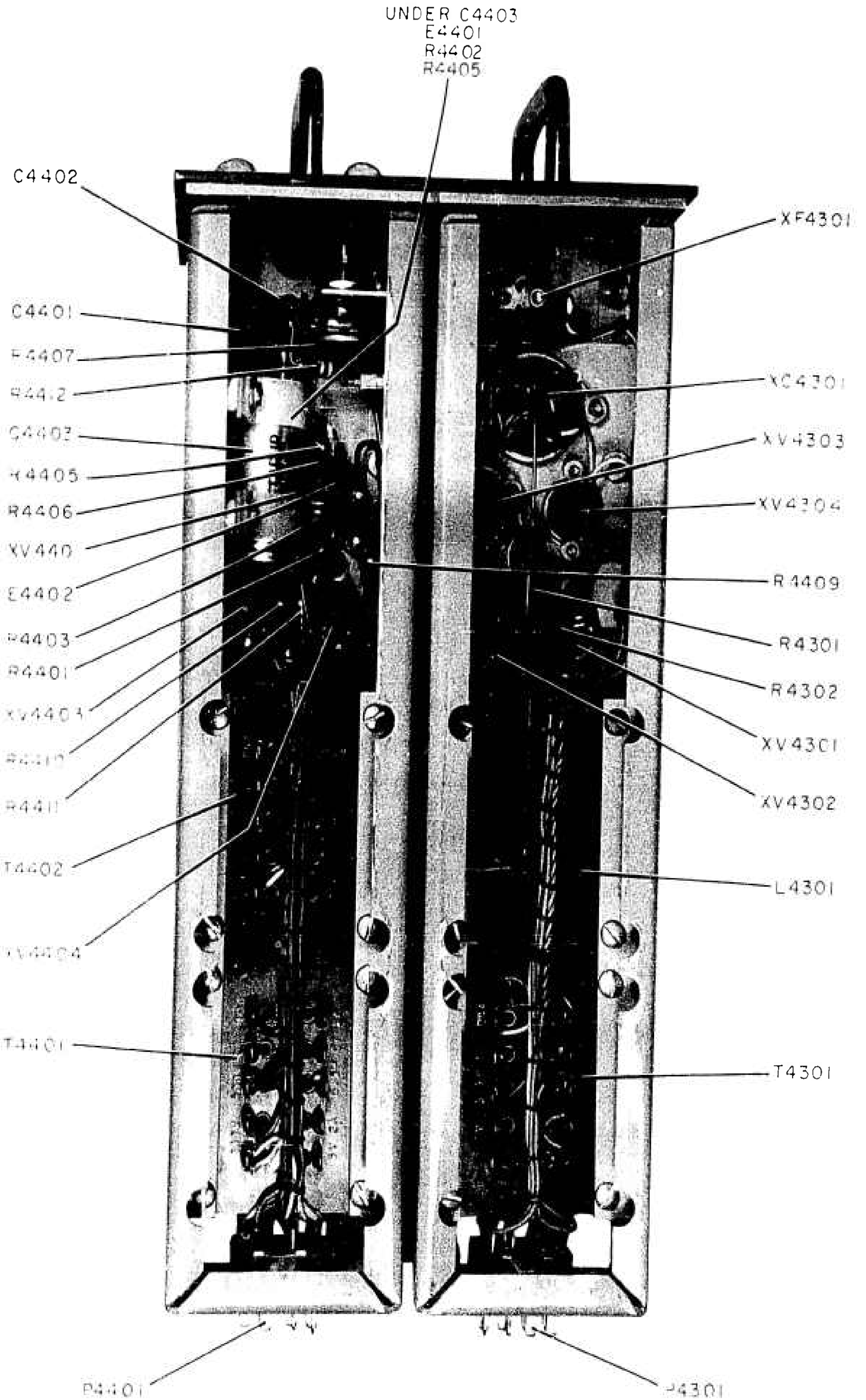


Figure 48. Servo Power Supply Z506 and Servo Amplifier Z507, Bottom View.

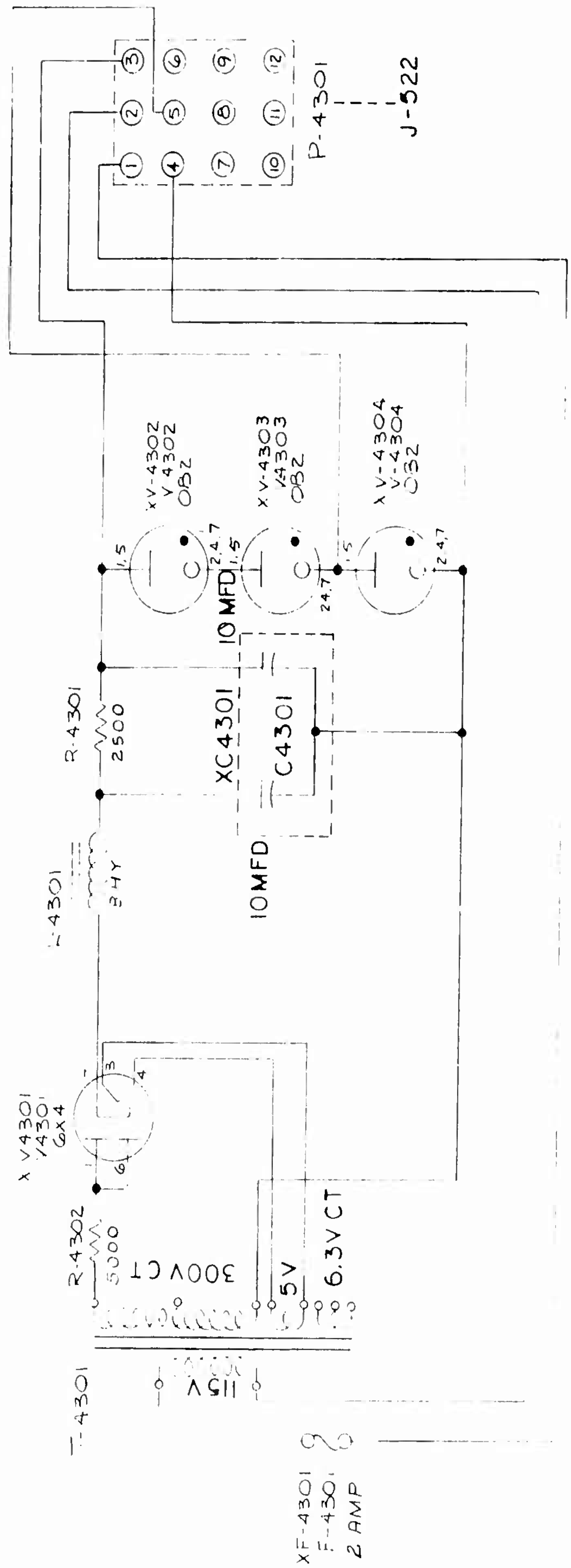


Figure 49. SchematicDiagram, Servo Power Supply Z506.

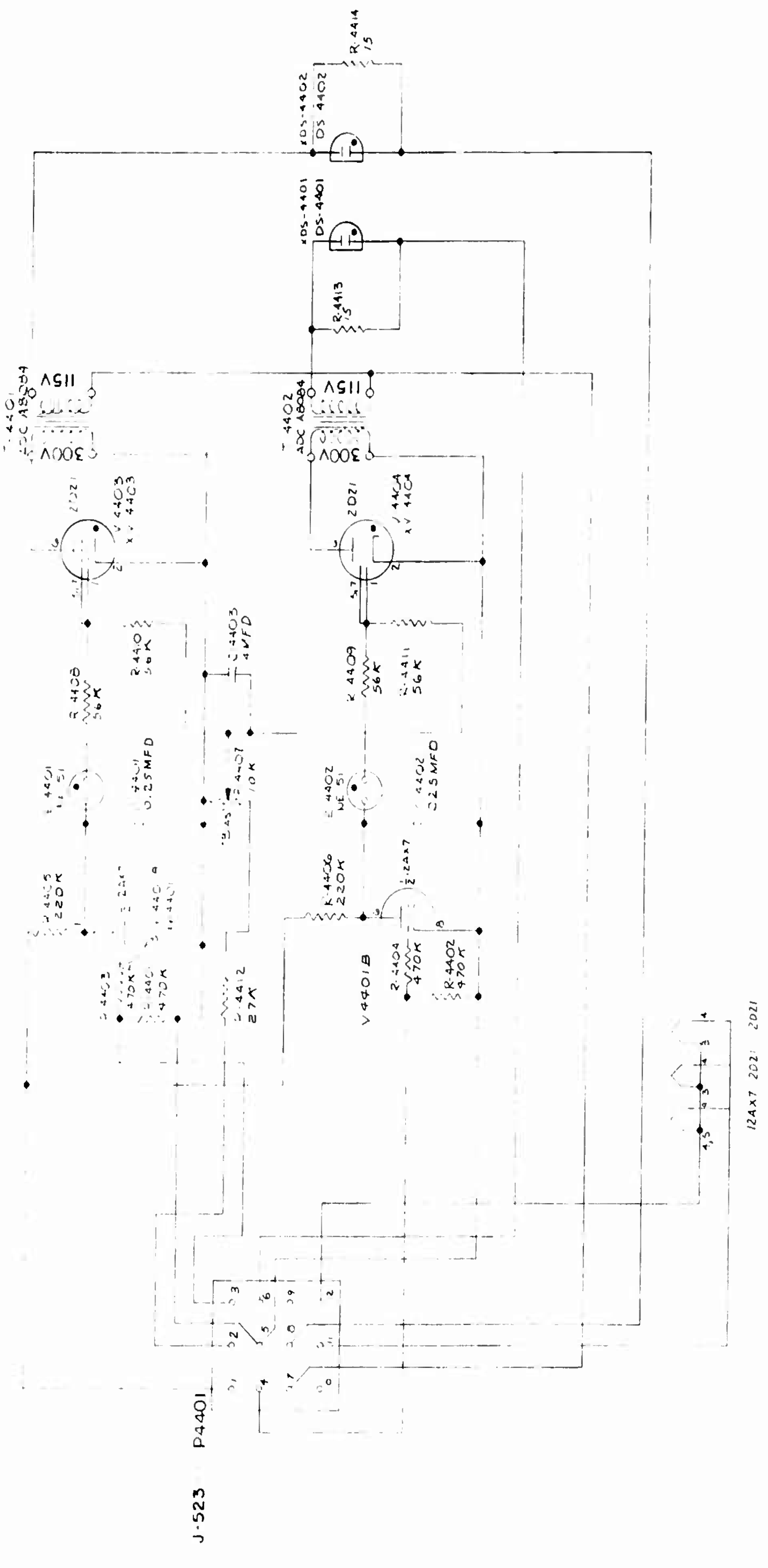


Figure 50. Schematic Diagram, Servo Amplifier Z507.

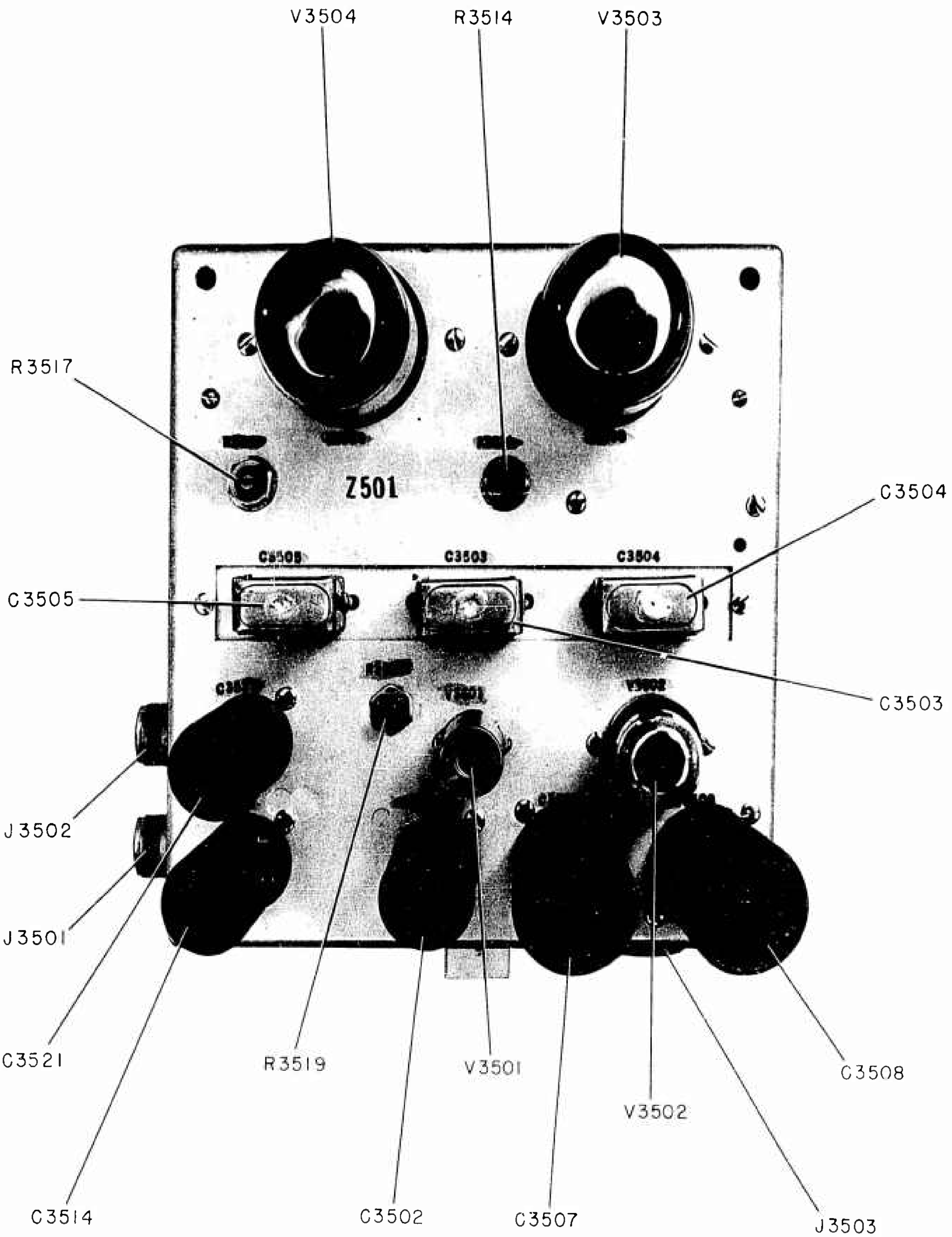


Figure 51. Feedback Amplifier Z501, Front View.

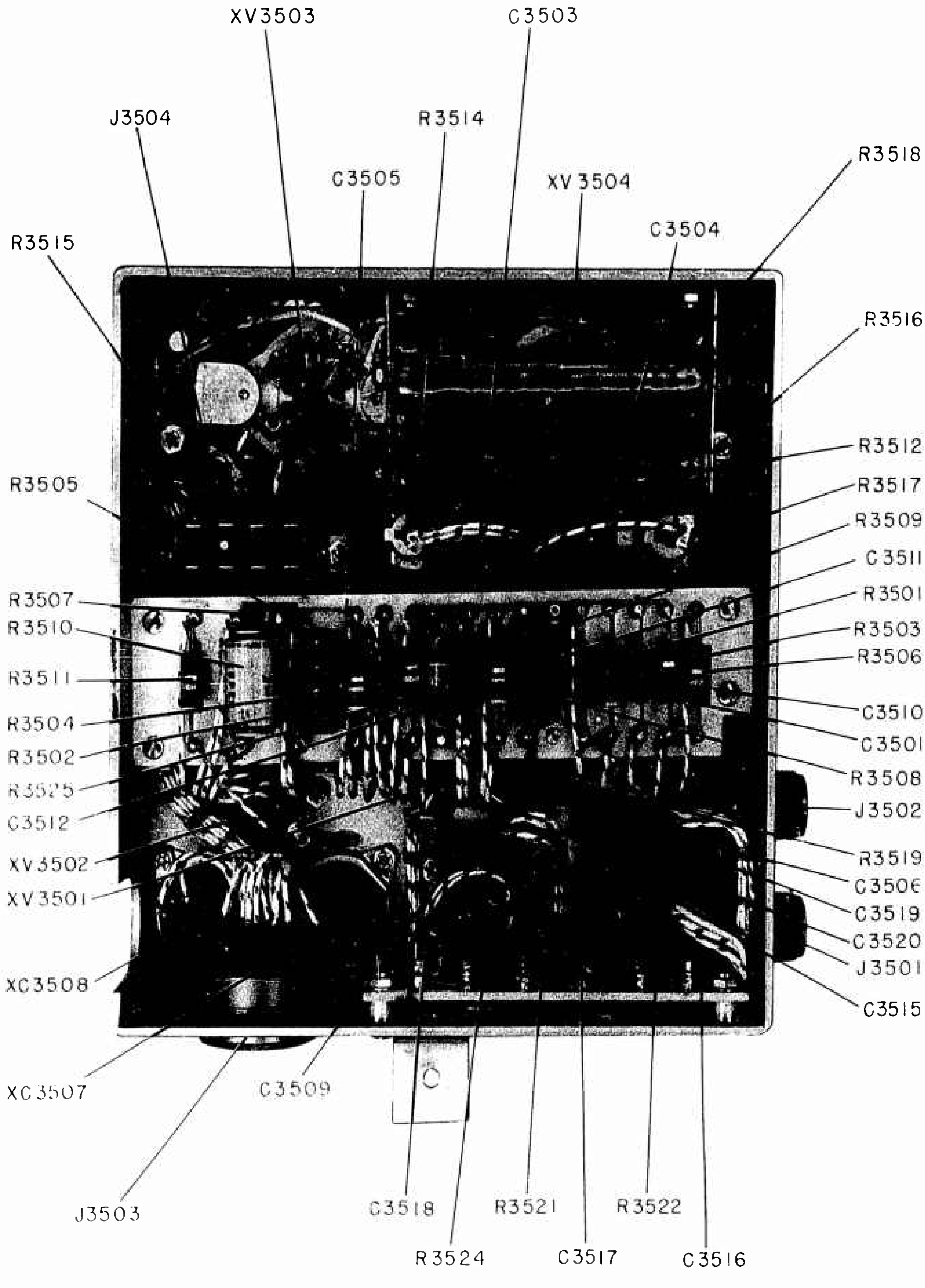


Figure 52. Feedback Amplifier Z501, Rear View.

Figure 53. Schematic Diagram, Feedback Amplifier Z501.

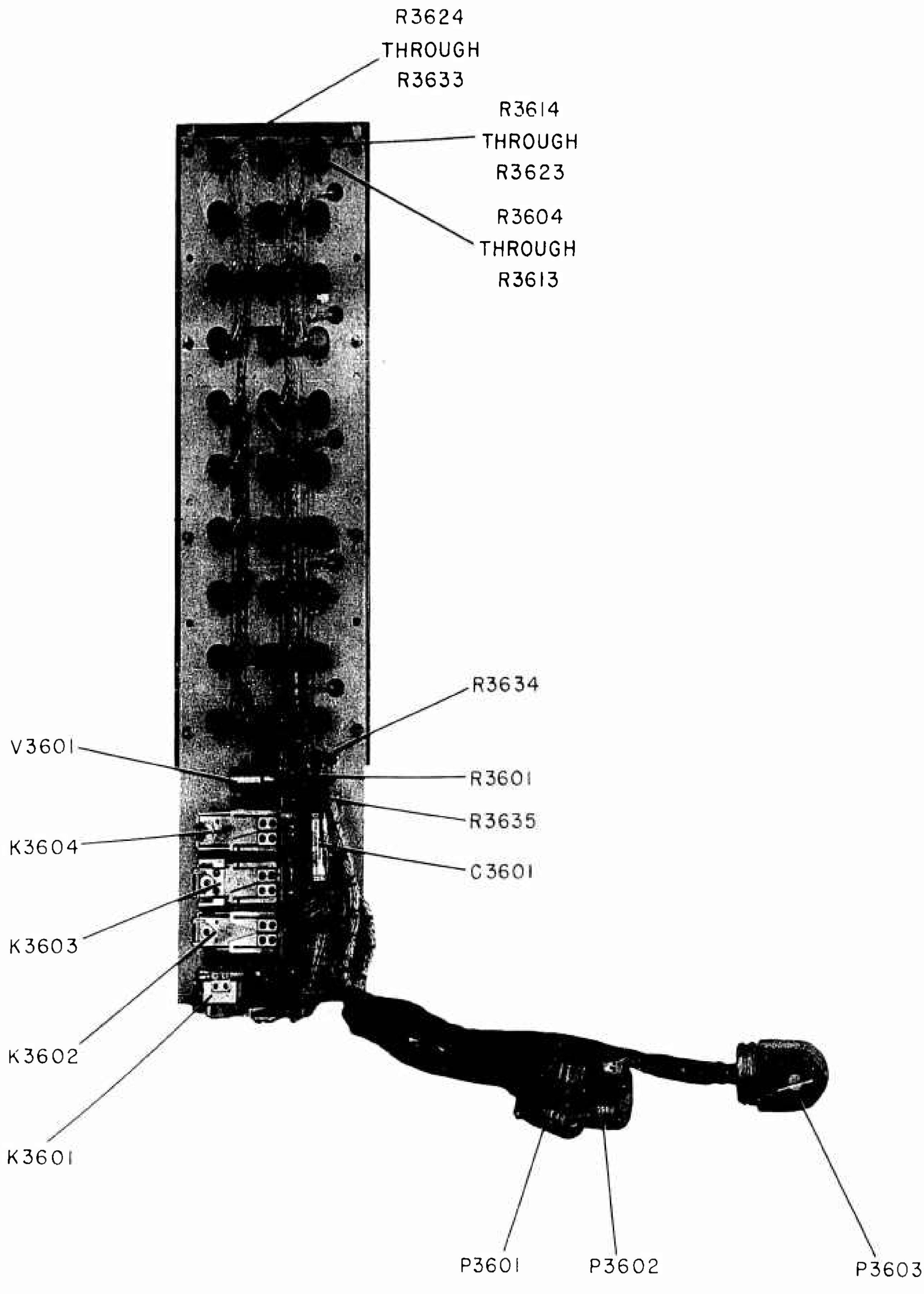


Figure 54. Servo Control Panel Z502, Rear View, Covers Removed.

Figure 55. Schematic Diagram, Servo Control Panel Z502.

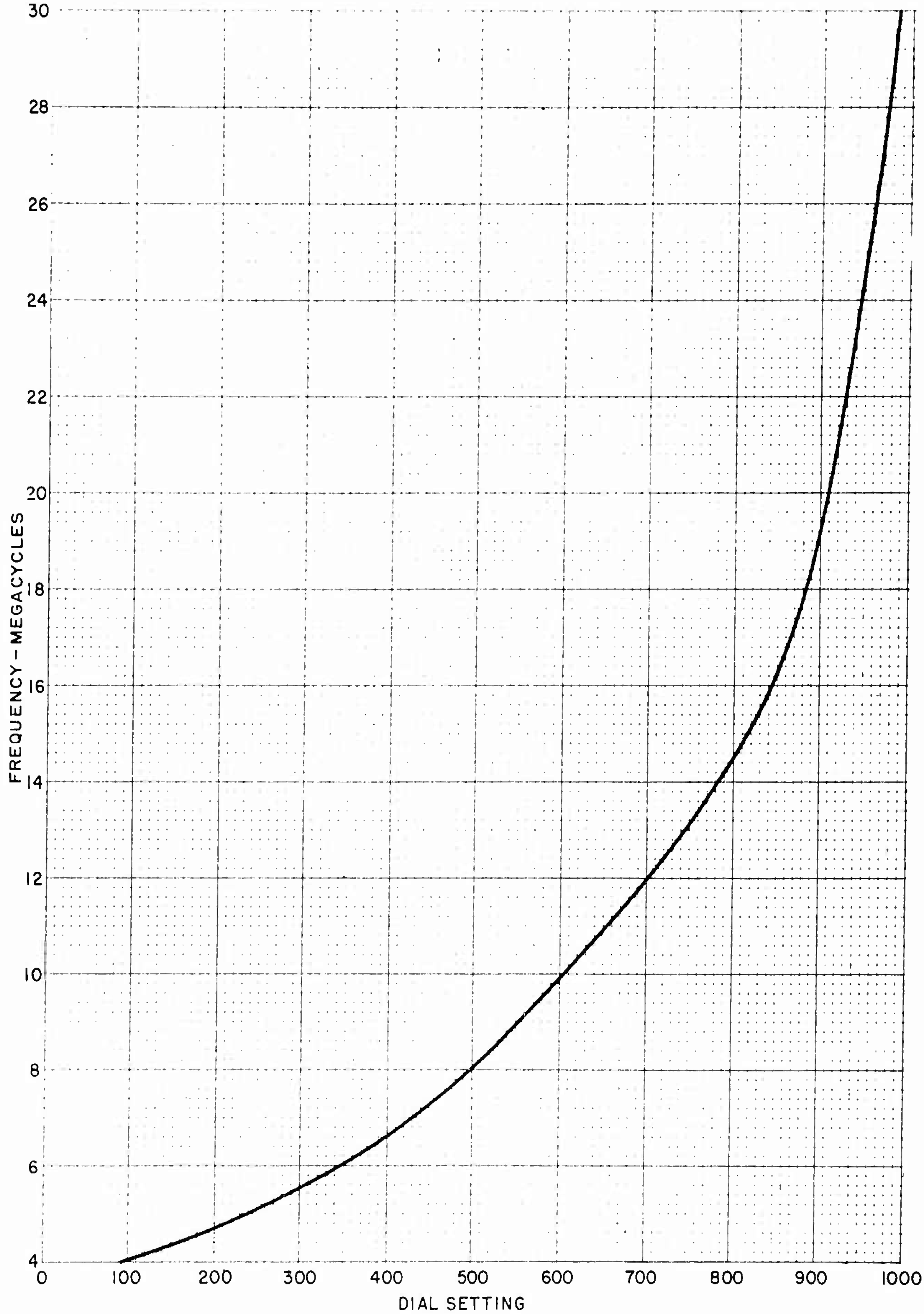


Figure 56. Tuning Chart, GRID TUNING Servo Control.

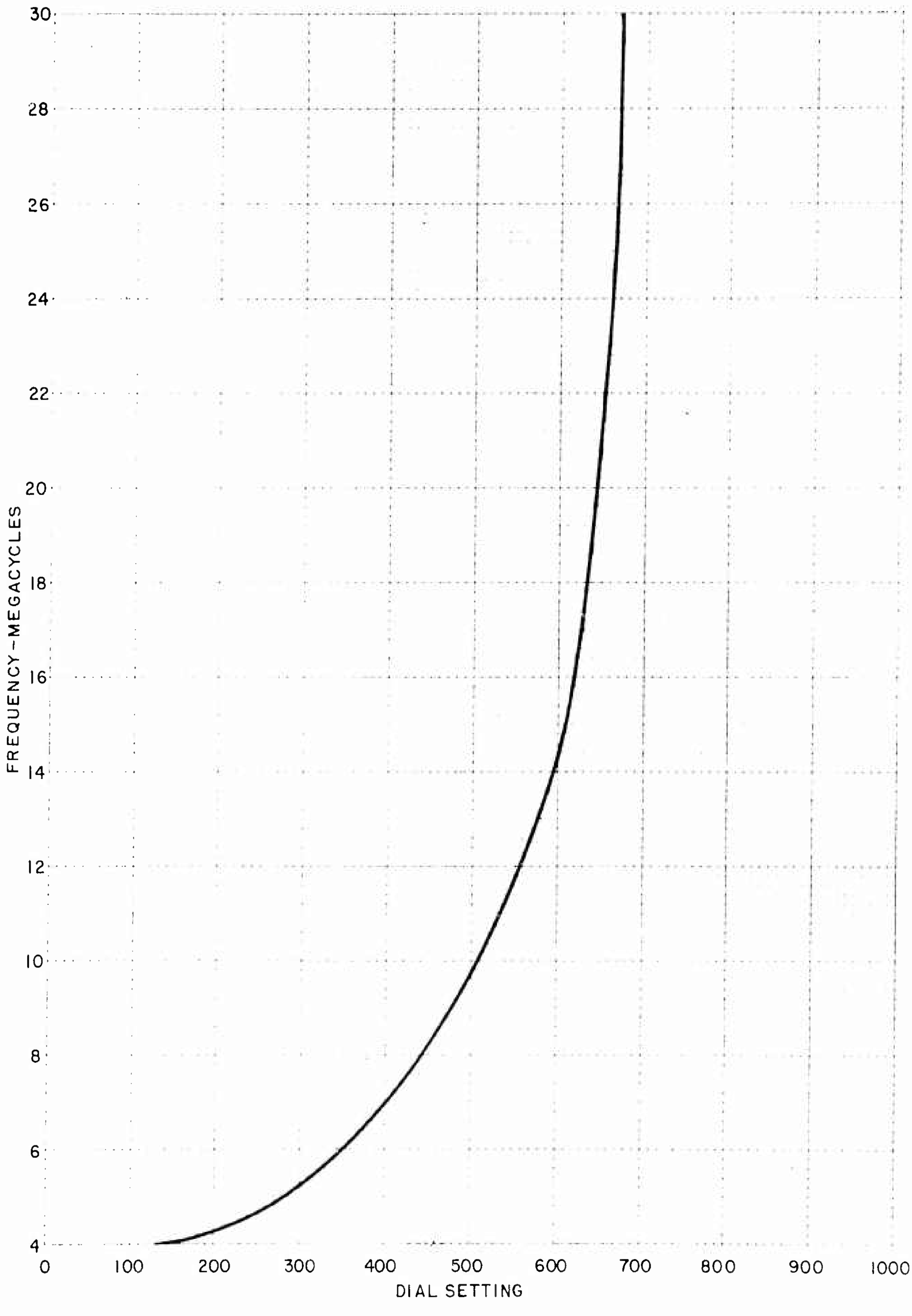


Figure 57. Tuning Chart, PLATE LOADING Servo Control.

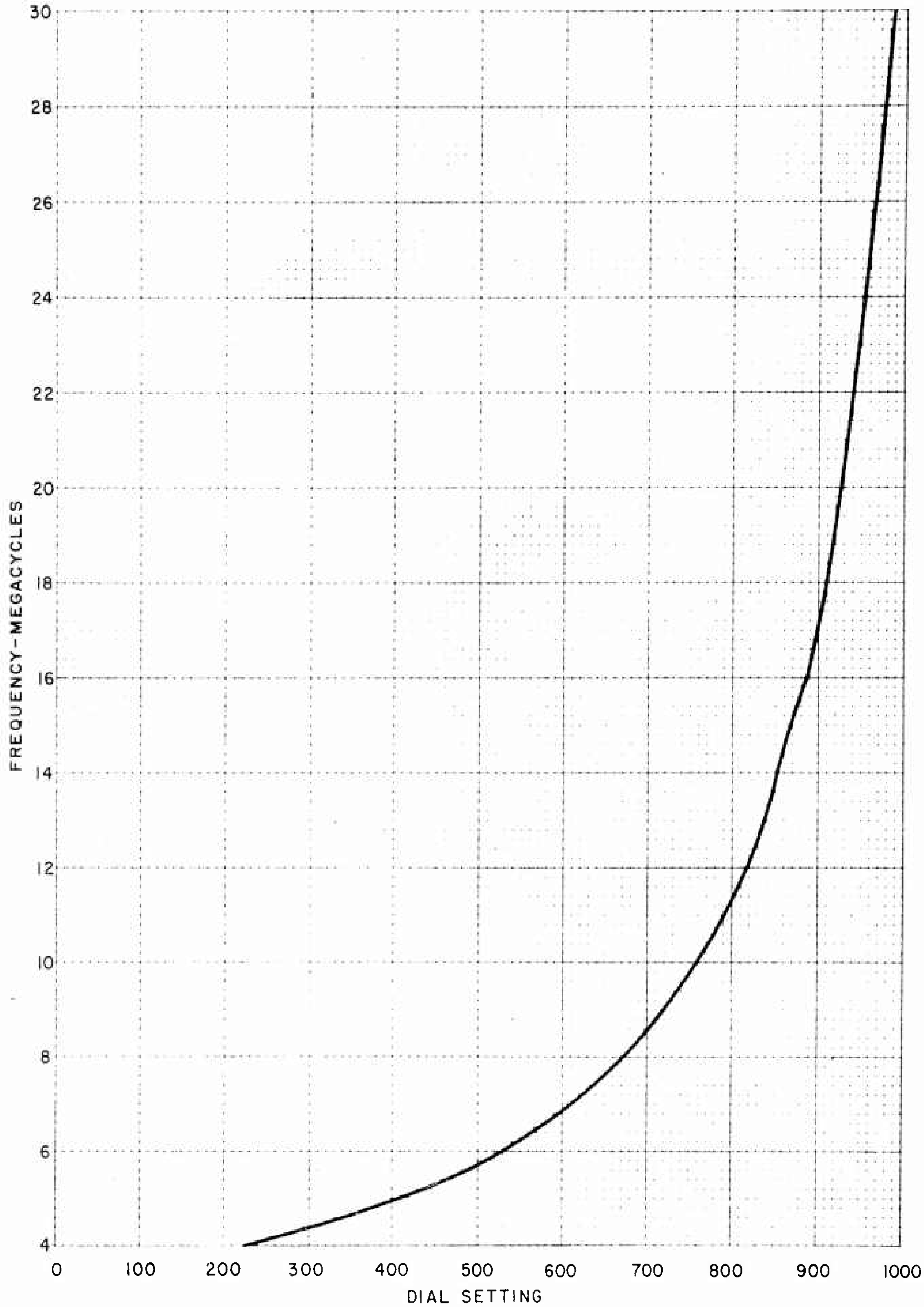


Figure 58. Tuning Chart, PLATE TUNING Servo Control.

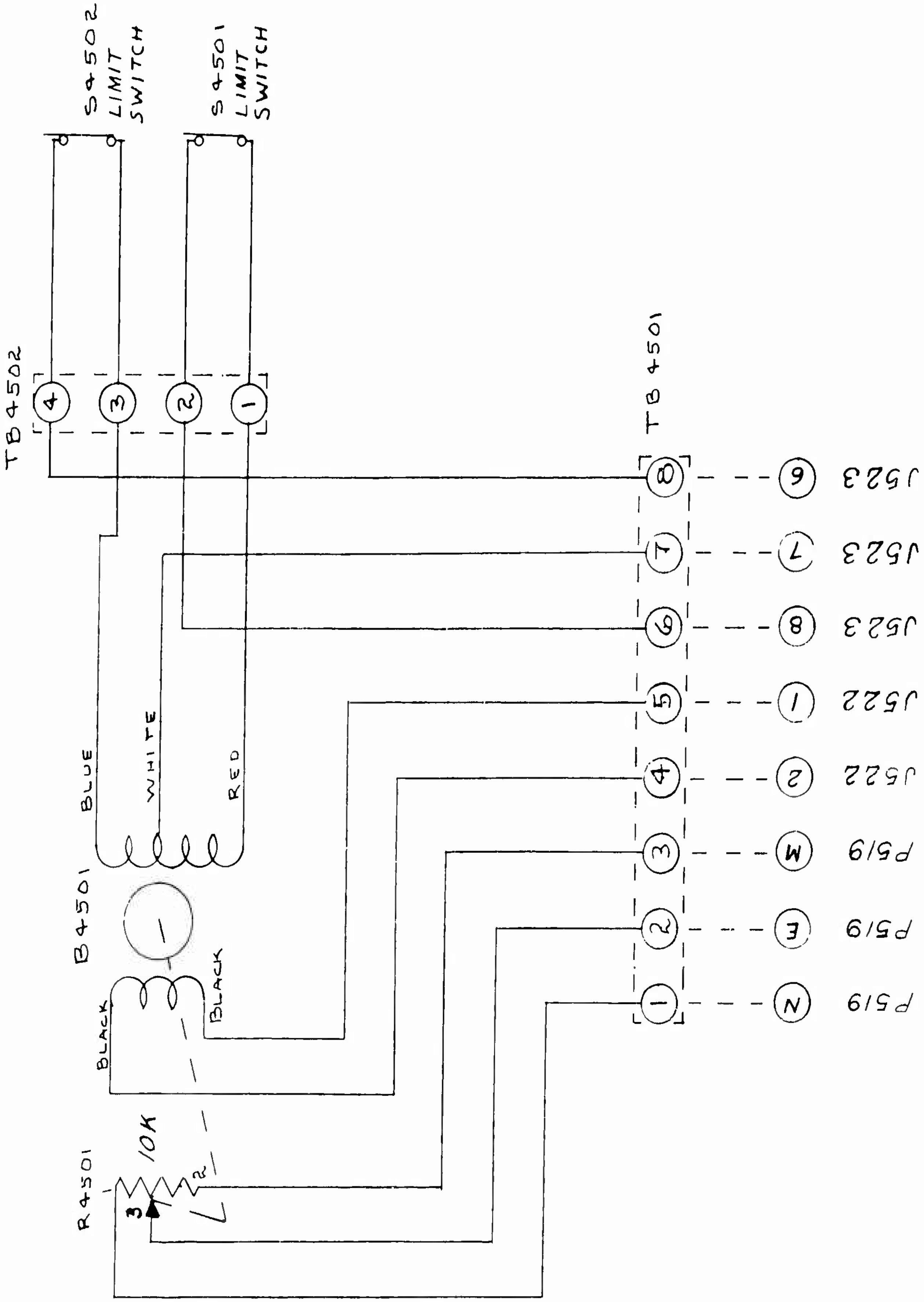


Figure 59. Schematic Diagram, Balance Potentiometer Servo Positioner Z508.

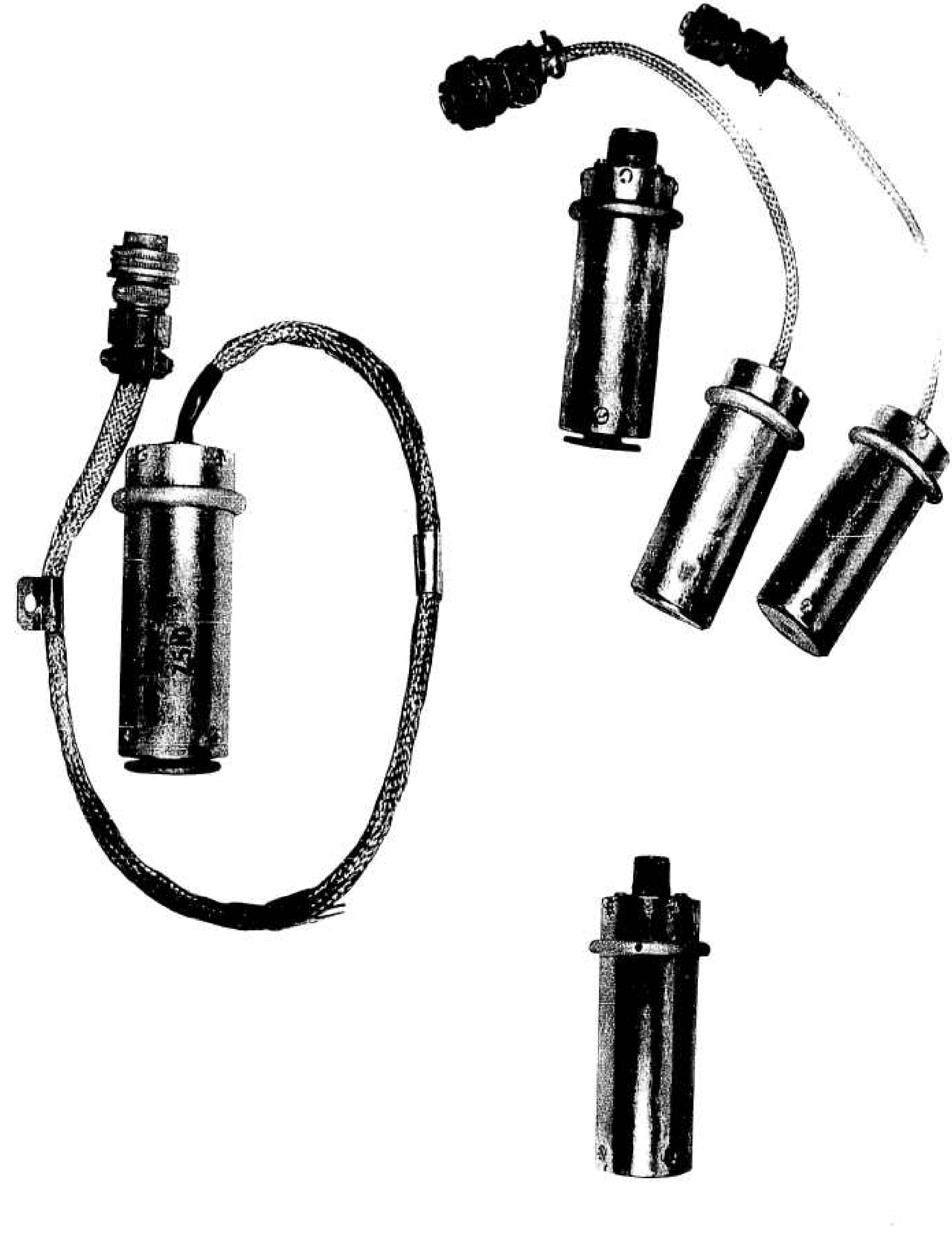


Figure 60. Probes Z503, Z504, Z505, Z509 and Z510.

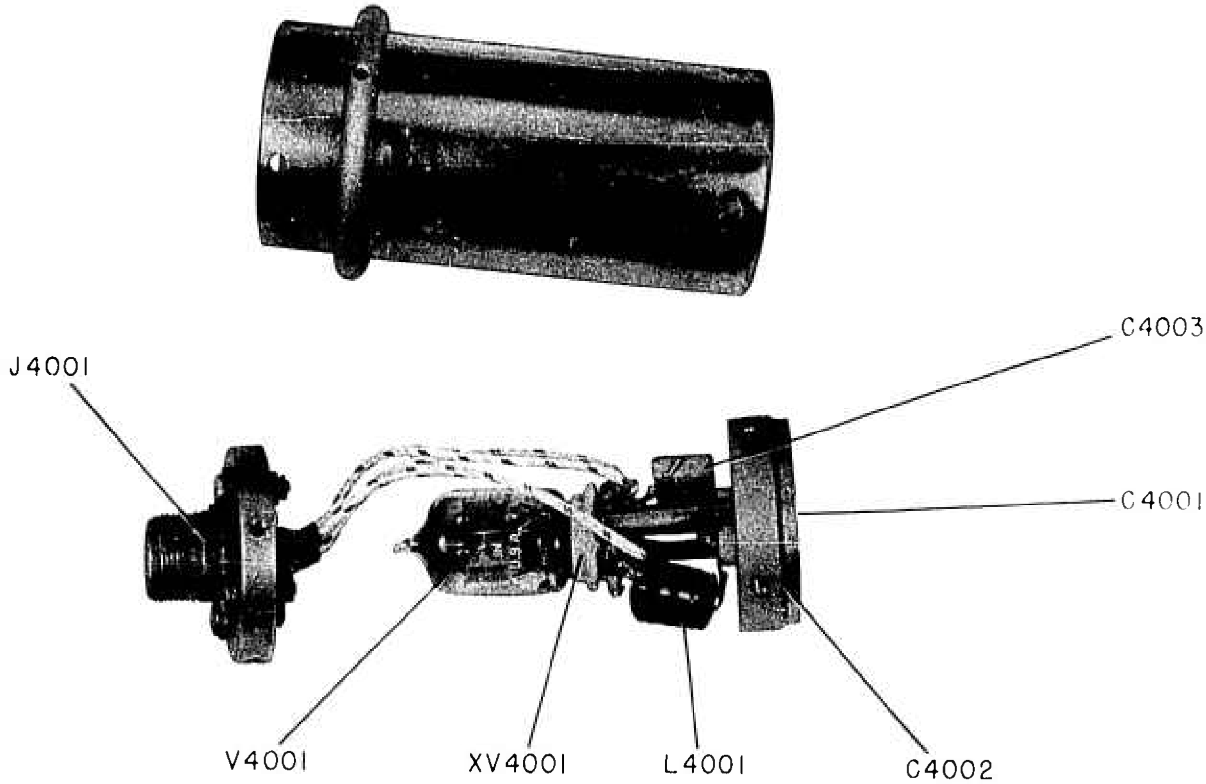


Figure 61A. Grid RF Voltmeter Probe Z503, Shell Removed.

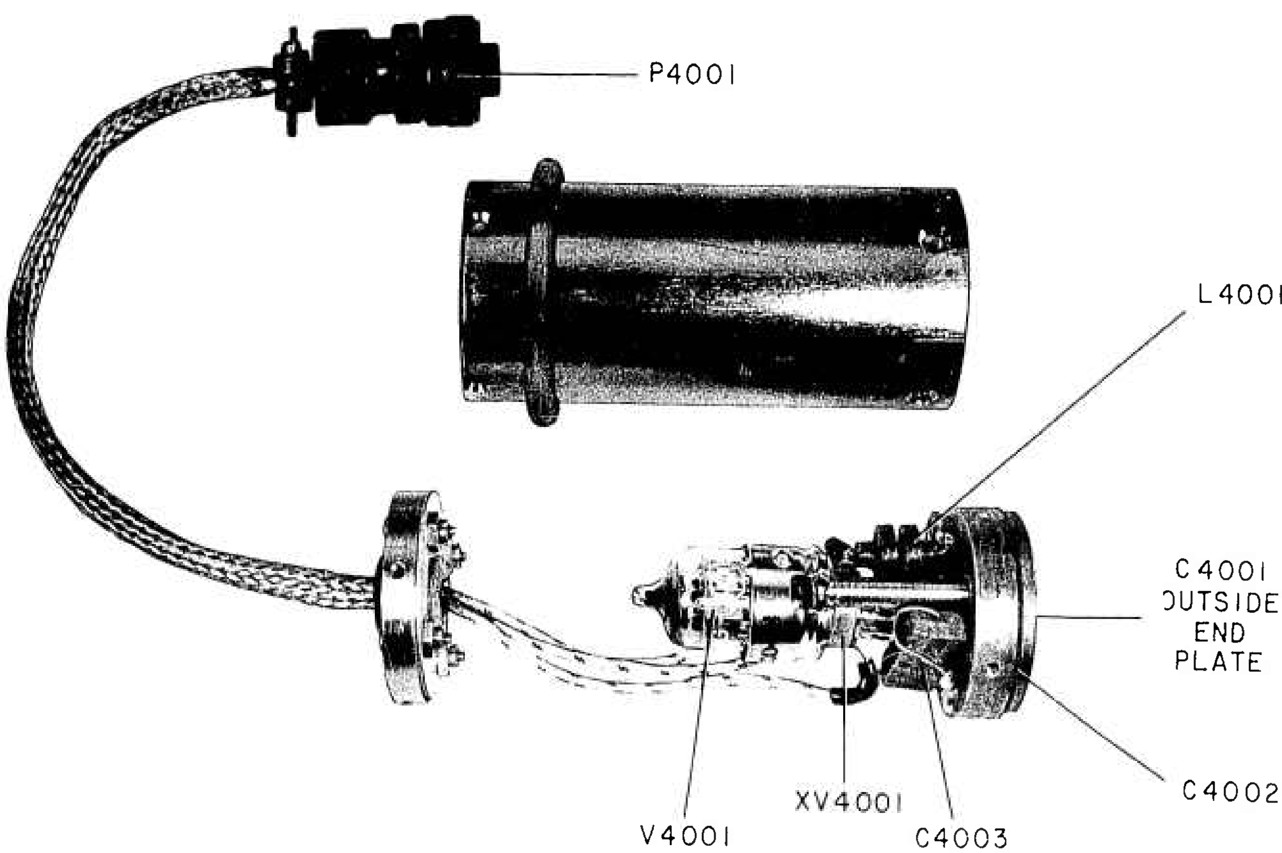


Figure 61B. Plate RF Voltmeter Probe Z504, Shell Removed.

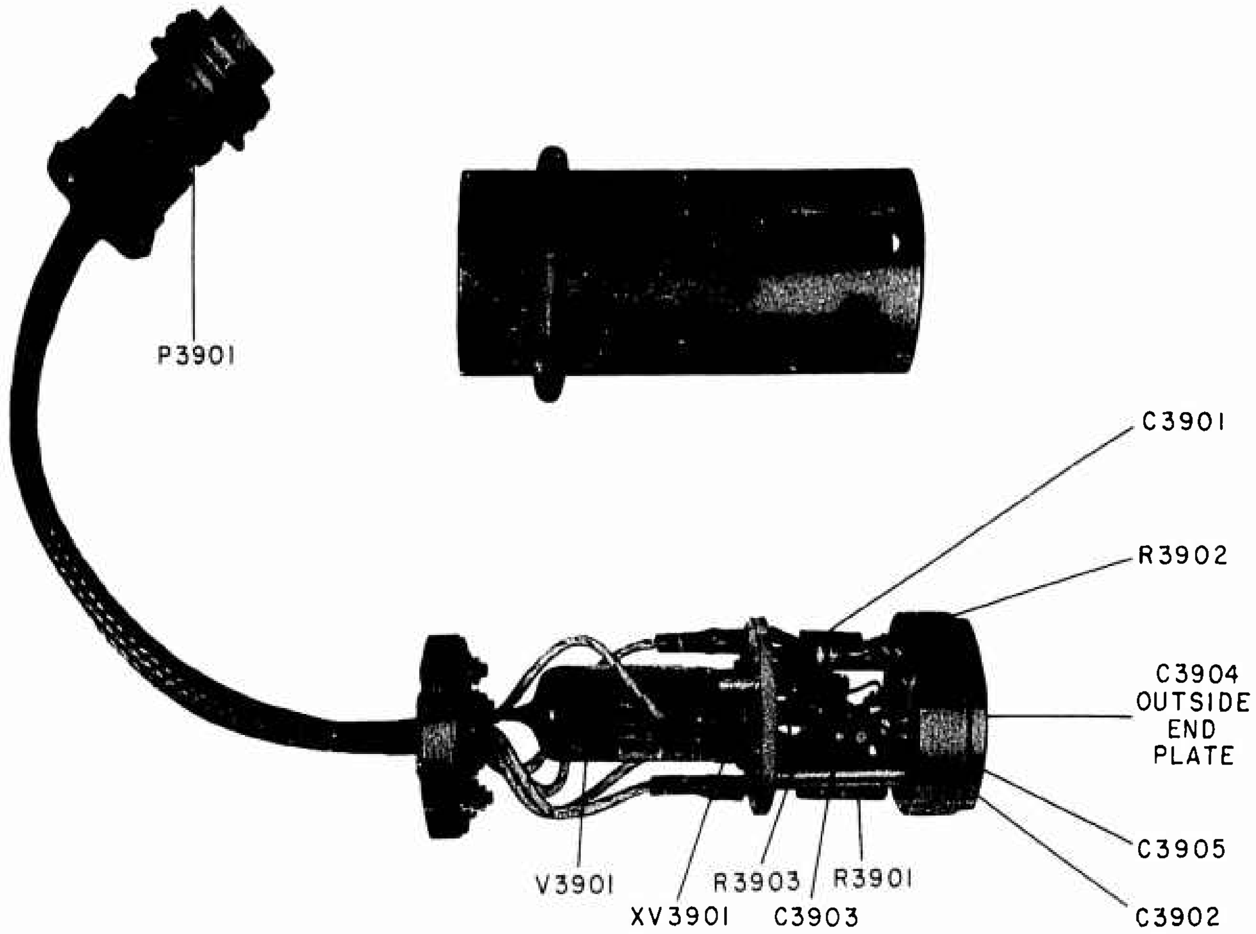


Figure 62 A. ALC Probe Z505, Shell Removed.

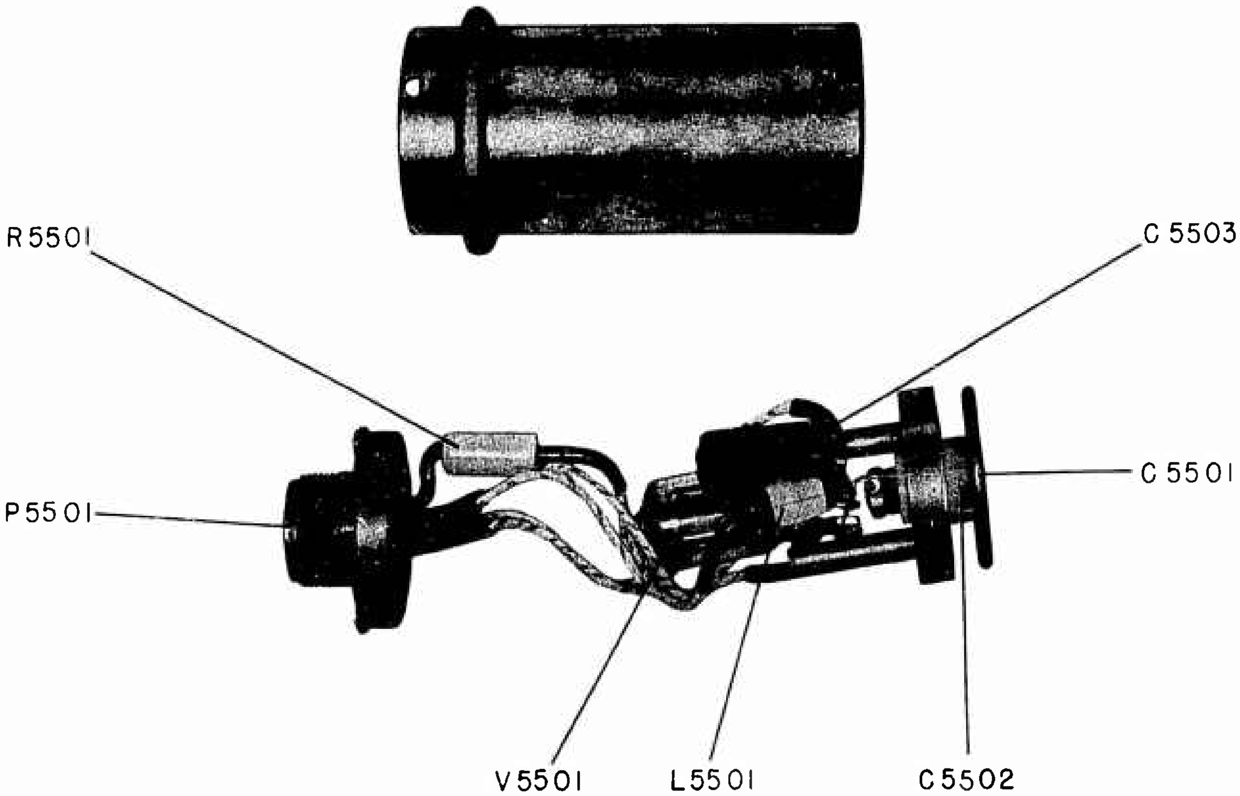


Figure 62 B. Grid Feedback Probe Z509, Shell Removed.

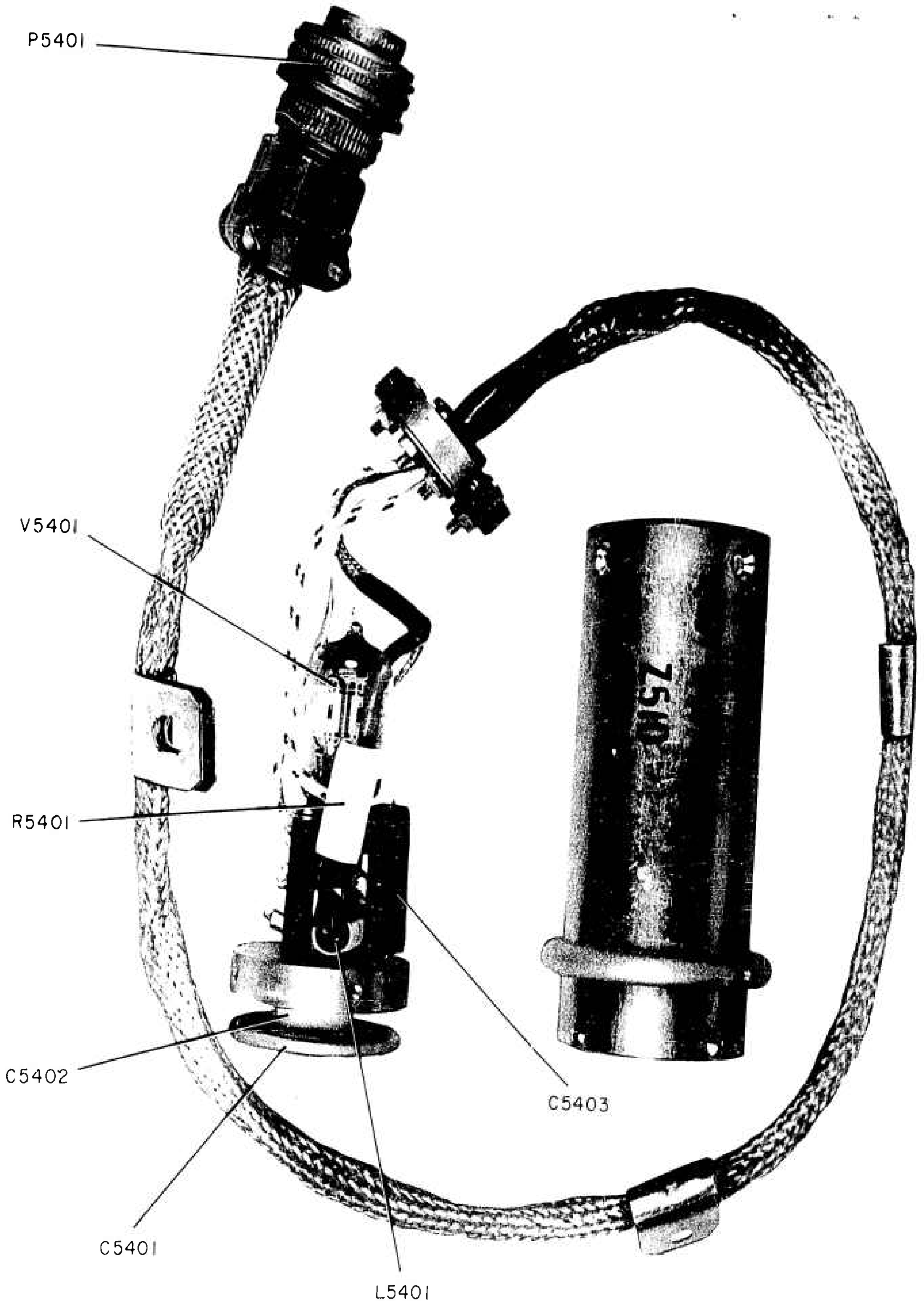


Figure 63. Plate Feedback Probe Z510, Shell Removed.

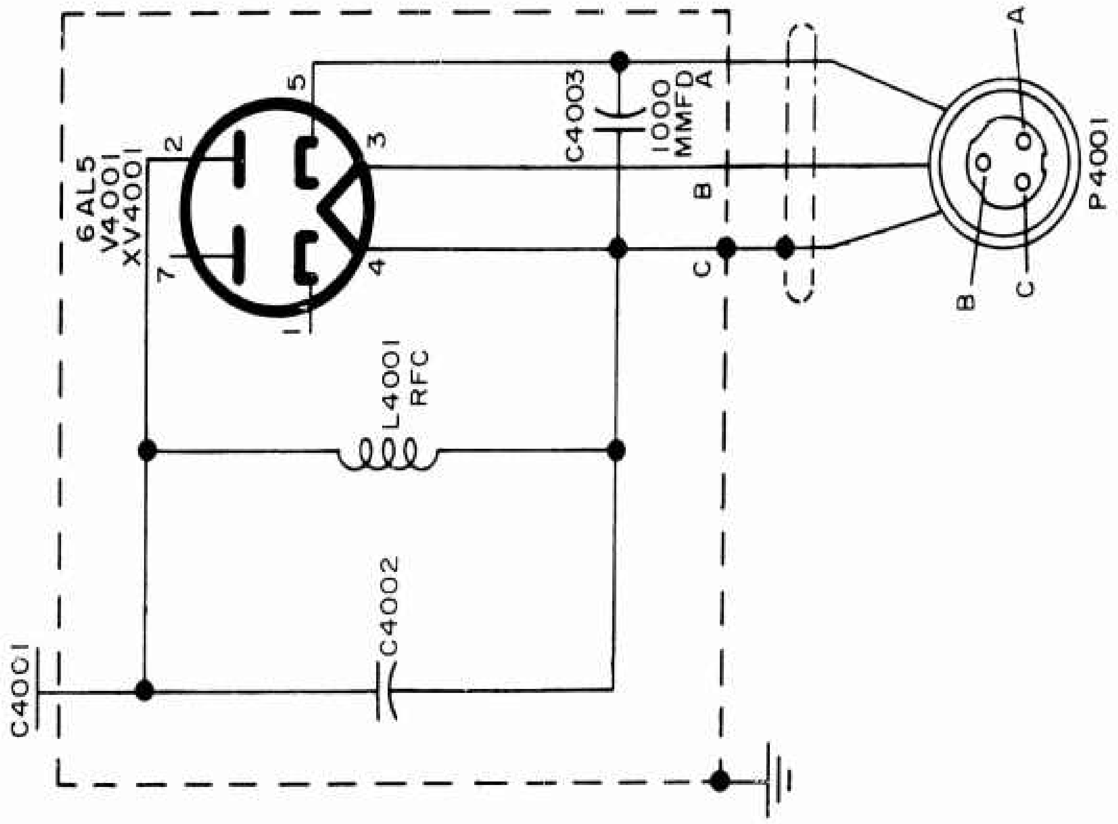


Figure 64. Schematic Diagram, RF Voltmeter Probe Z503 or Z504.

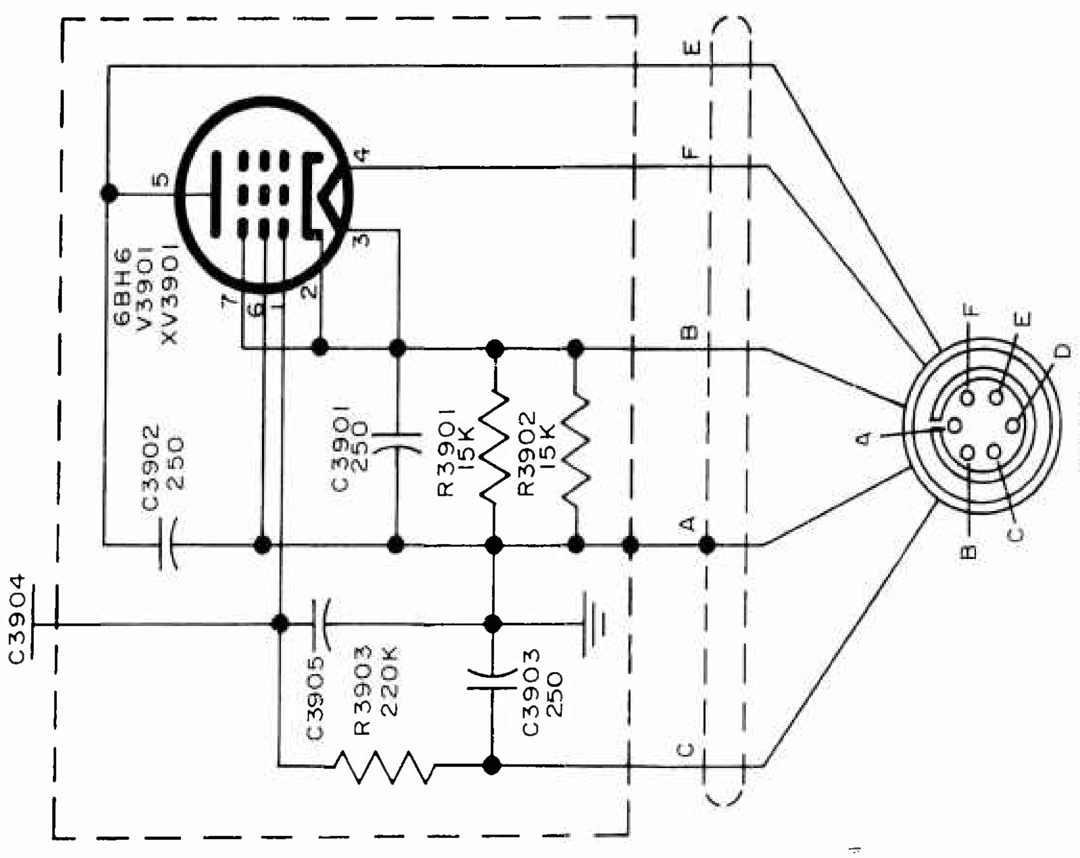


Figure 65. Schematic Diagram, ALC Probe Z505.

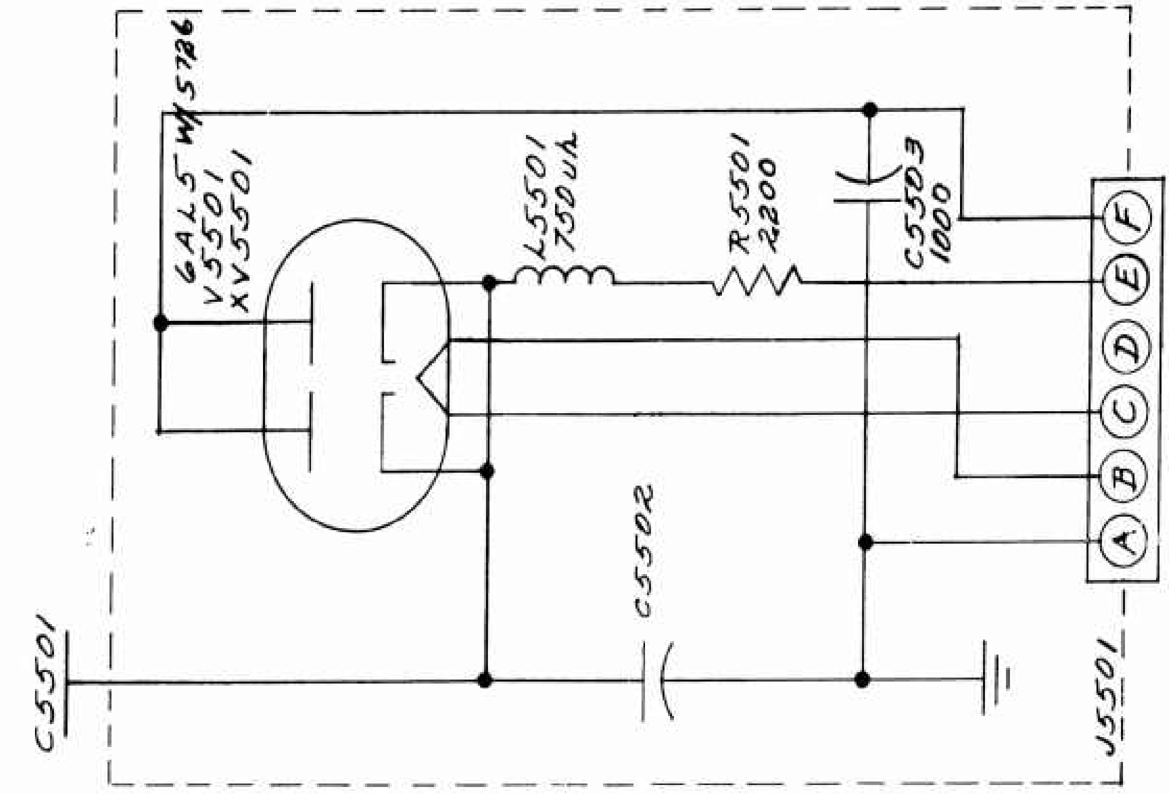


Figure 66. Schematic Diagram, Grid Feedback Probe Z509.

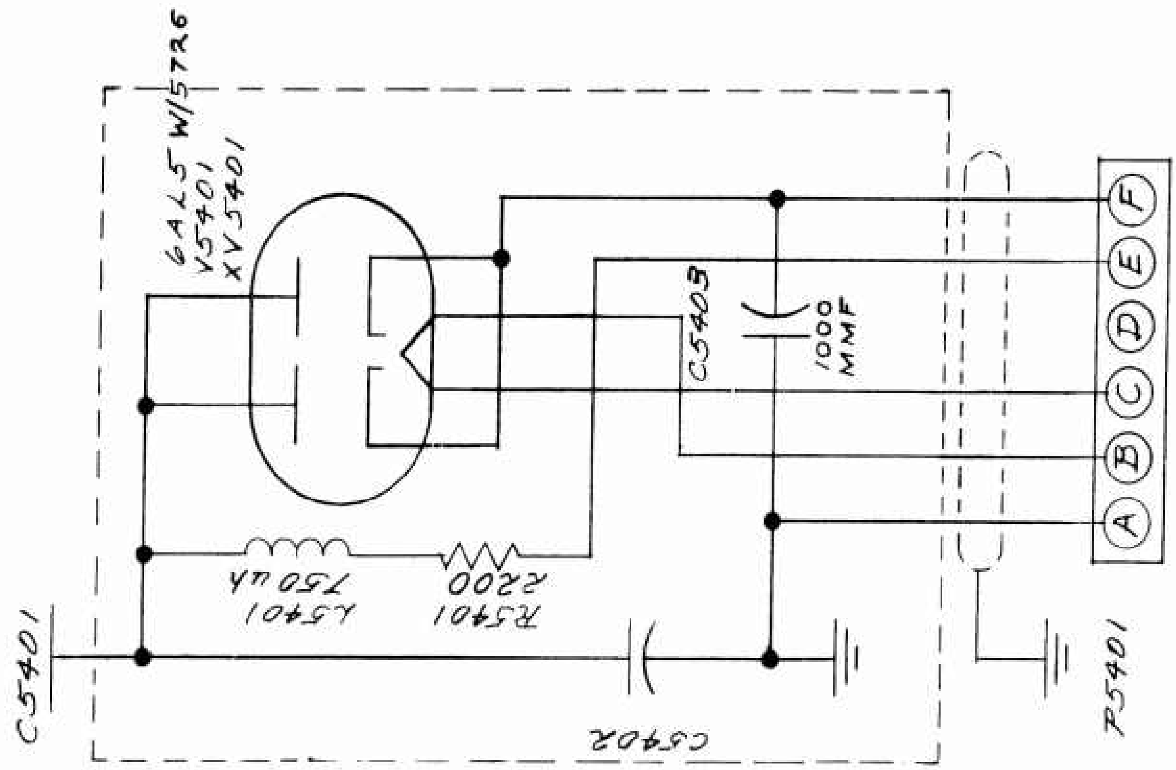


Figure 67. Schematic Diagram, Plate Feedback Probe Z510.

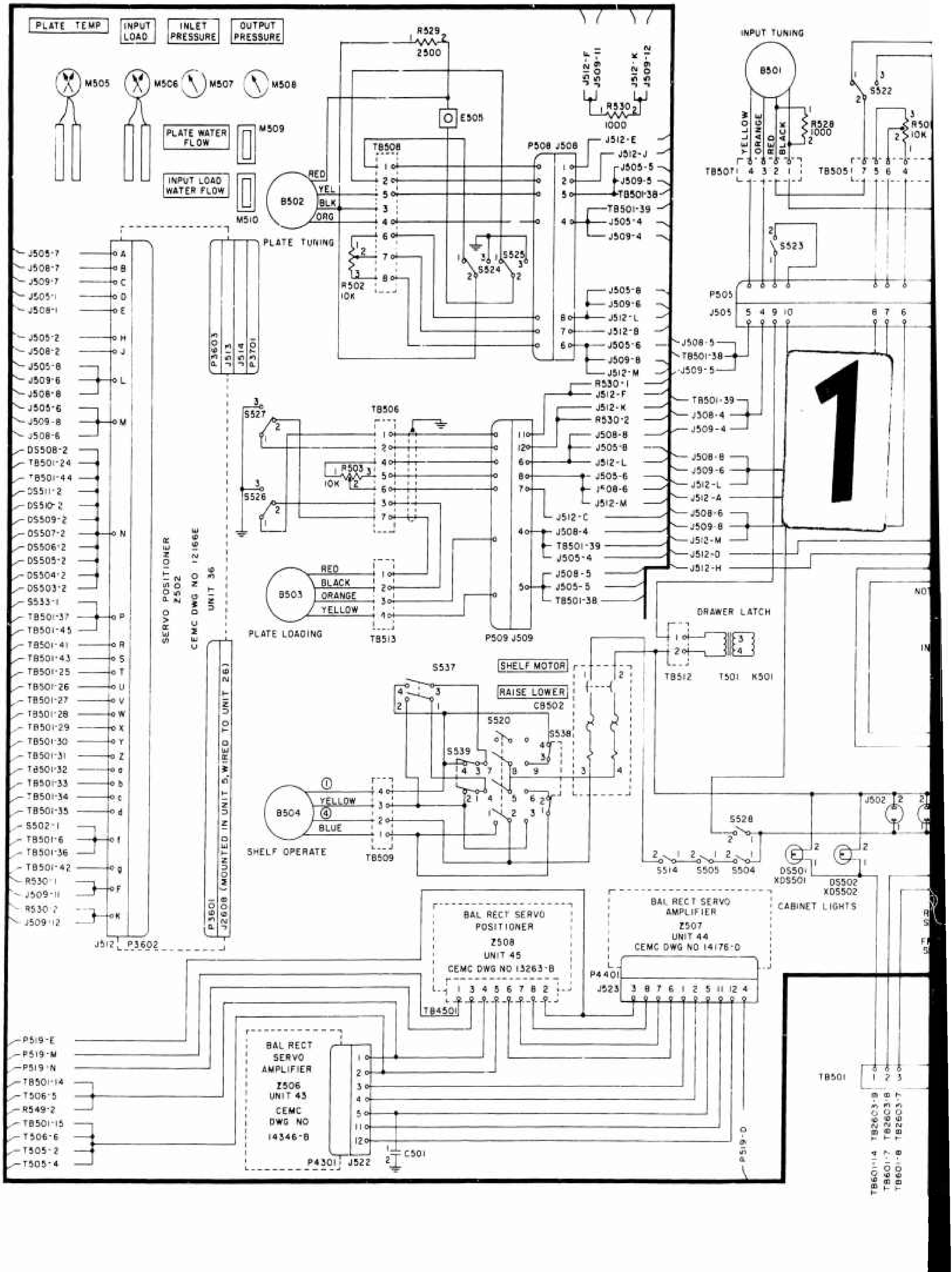
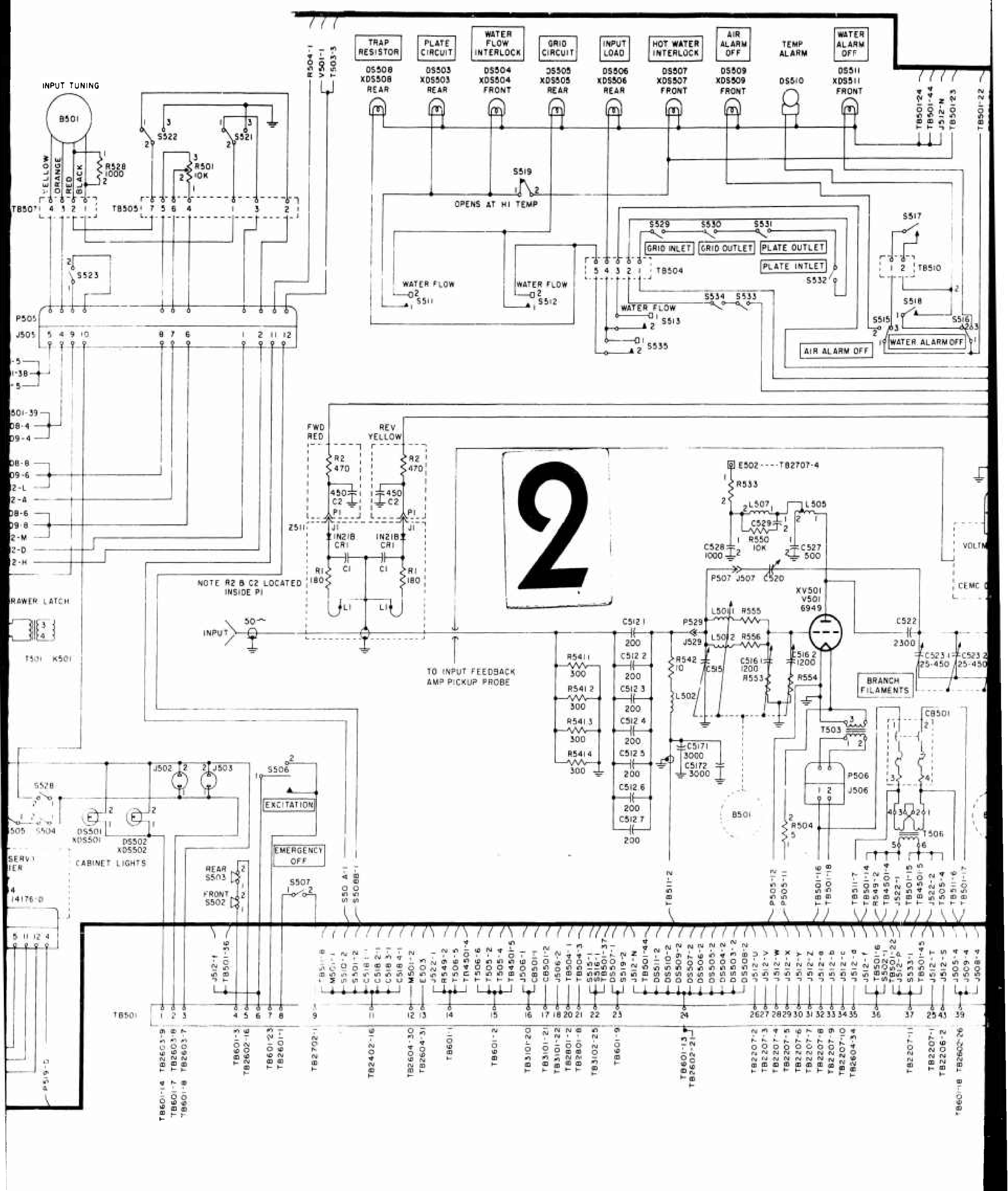
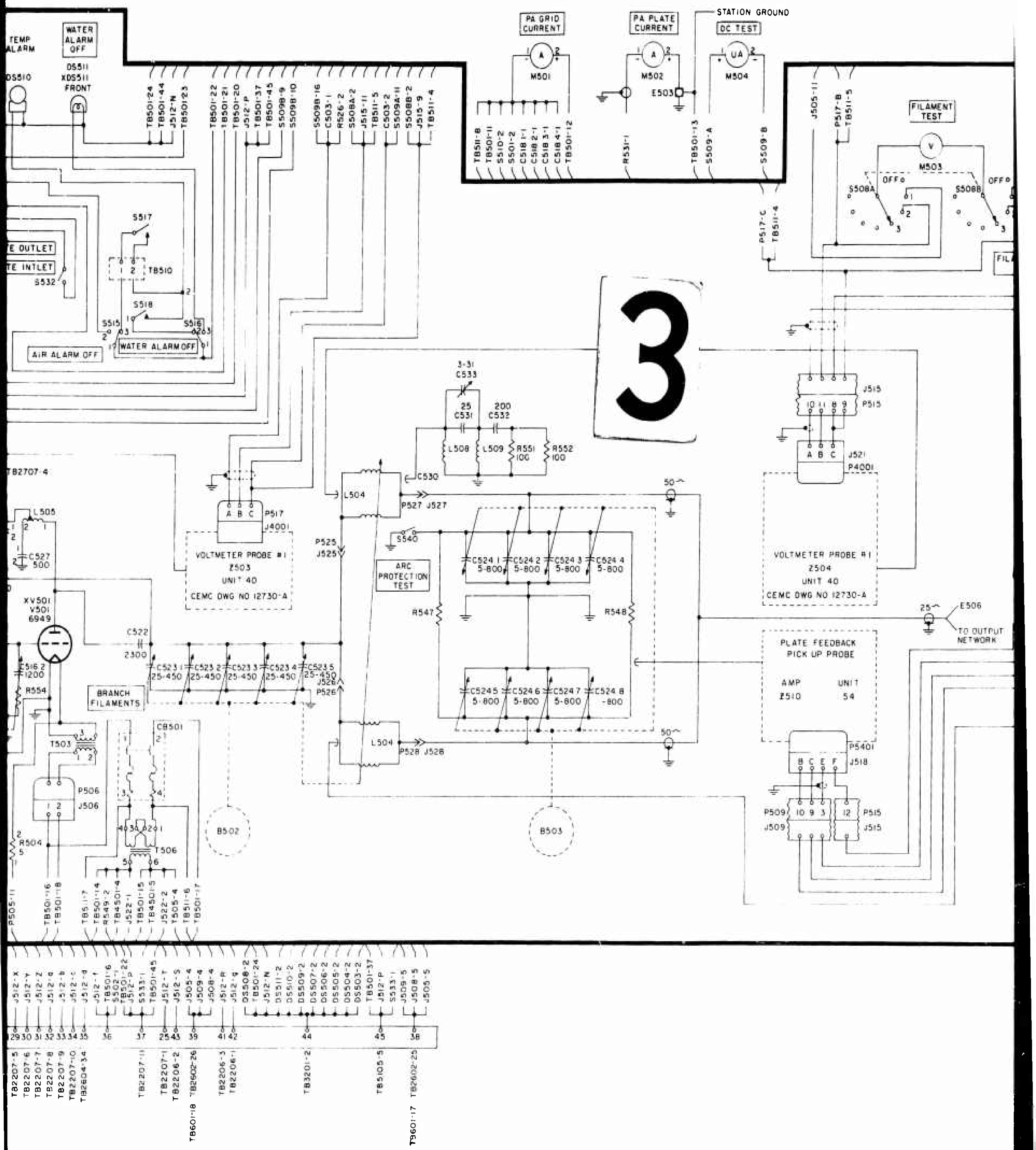


PLATE TEMP
INPUT LOAD
INLET PRESSURE
OUTPUT PRESSURE
M505
M506
M507
M508
PLATE WATER FLOW
M509
INPUT LOAD WATER FLOW
M510
R529
2500
E505
R530
1000
B502
PLATE TUNING
TB508
R502
10K
P508 J508
S524
S525
INPUT TUNING
B501
YELLOW
ORANGE
RED
BLACK
R528
1000
S522
R501
10K
TB507
TB505
S523
P505
J505
SERVO POSITIONER
Z502
CEMC DWG NO 12166E
UNIT 36
P3603
J513
J514
P3701
S527
S526
TB506
R503
10K
P509 J509
B503
PLATE LOADING
TB513
DRAWER LATCH
TB512
T501
K501
S537
SHELF MOTOR
RAISE LOWER
CB502
S520
S538
S539
B504
SHELF OPERATE
TB509
P3601
J2608 (MOUNTED IN UNIT 5, WIRED TO UNIT 26)
J512
P3602
S528
S514
S505
S504
DS501
XDS501
DS502
XDS502
CABINET LIGHTS
J502
BAL RECT SERVO POSITIONER
Z508
UNIT 45
CEMC DWG NO 13263-B
TB4501
BAL RECT SERVO AMPLIFIER
Z507
UNIT 44
CEMC DWG NO 14176-D
P4401
J523
BAL RECT SERVO AMPLIFIER
Z506
UNIT 43
CEMC DWG NO 14346-B
P4301
J522
C501
TB501
1



INPUT TUNING
B501
TRAP RESISTOR
PLATE CIRCUIT
WATER FLOW INTERLOCK
GRID CIRCUIT
INPUT LOAD
HOT WATER INTERLOCK
AIR ALARM OFF
TEMP ALARM
WATER ALARM OFF
OPENS AT HI TEMP
GRID INLET
GRID OUTLET
PLATE OUTLET
PLATE INTLET
WATER FLOW
AIR ALARM OFF
WATER ALARM OFF
FWD RED
REV YELLOW
NOTE R2 & C2 LOCATED INSIDE P1
INPUT
TO INPUT FEEDBACK AMP PICKUP PROBE
BRANCH FILAMENTS
DRAWER LATCH
CABINET LIGHTS
EXCITATION
EMERGENCY OFF
2



TEMP ALARM
WATER ALARM OFF
DS510
DS511
XDS511
FRONT
PA GRID CURRENT
M501
PA PLATE CURRENT
M502
E503
STATION GROUND
DC TEST
M504
FILAMENT TEST
M503
S508A
S508B
OFF
R531-1
S517
TB510
S518
S532
S515
S516
AIR ALARM OFF
WATER ALARM OFF
3
3-31
C533
25
C531
200
C532
L508
L509
R551
100
R552
100
C530
L504
P527 J527
P525
J525
S540
ARC PROTECTION TEST
C524 1
C524 2
C524 3
C524 4
5-800
R547
R548
C5245
C524 6
C524 7
C524 8
P528 J528
50~
25~
E506
TO OUTPUT NETWORK
J515
P515
J521
P4001
VOLTMETER PROBE #1
Z503
UNIT 40
CEMC DWG NO 12730-A
P517
J4001
VOLTMETER PROBE R1
Z504
PLATE FEEDBACK PICK UP PROBE
AMP
Z510
UNIT
54
P5401
J518
P509
J509
TB2707-4
L505
C527
500
XV501
V501
6949
C522
2300
C523 1
C523 2
C523 3
C523 4
C523 5
25-450
J526
P526
C516 2
1200
R554
BRANCH FILAMENTS
T503
P506
J506
R504
CB501
T506
B502
B503
P505-11
TB501-16
TB501-18
TB601-18
TB601-17

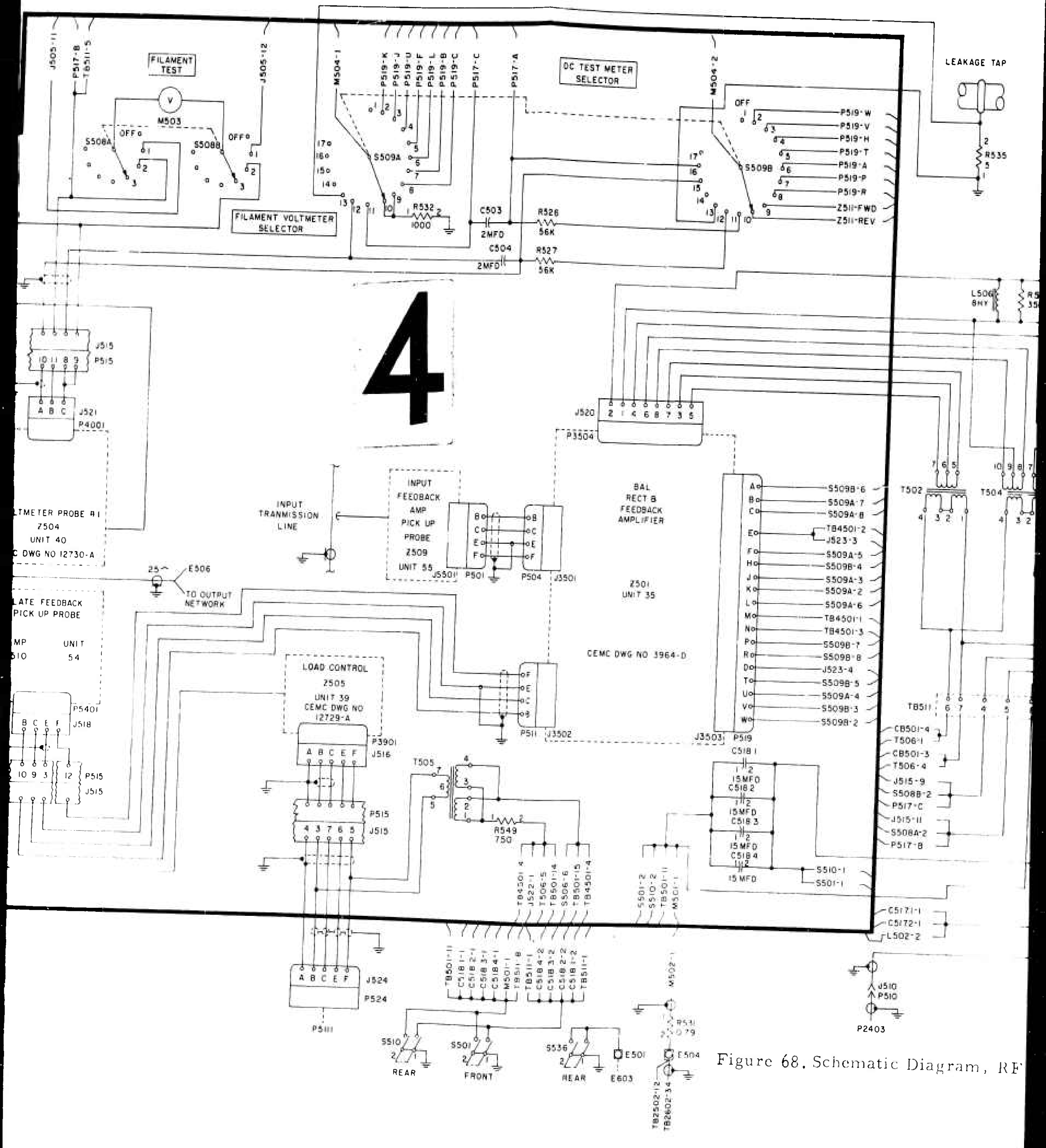


Figure 68. Schematic Diagram, RF

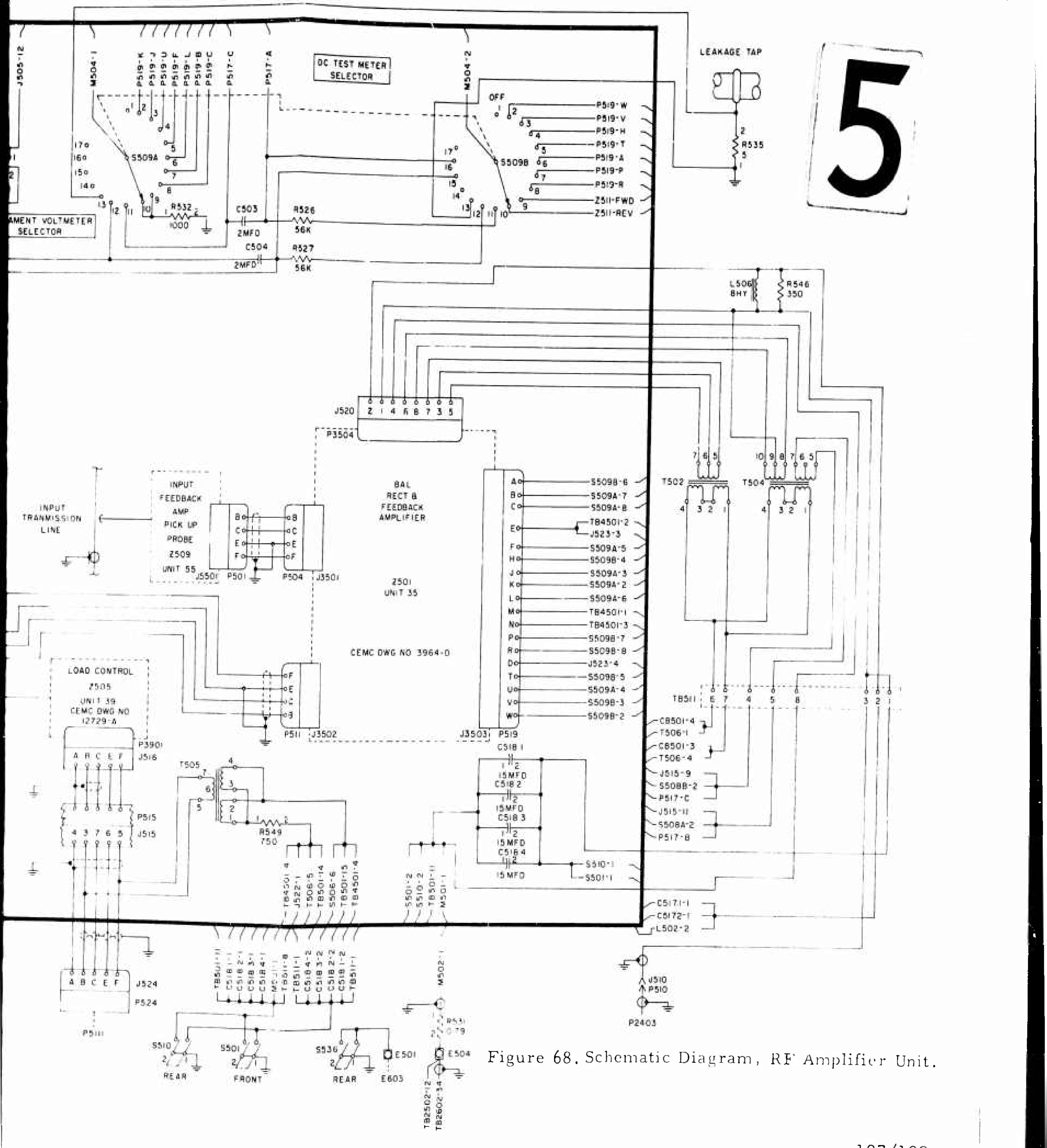


Figure 68. Schematic Diagram, RF Amplifier Unit.

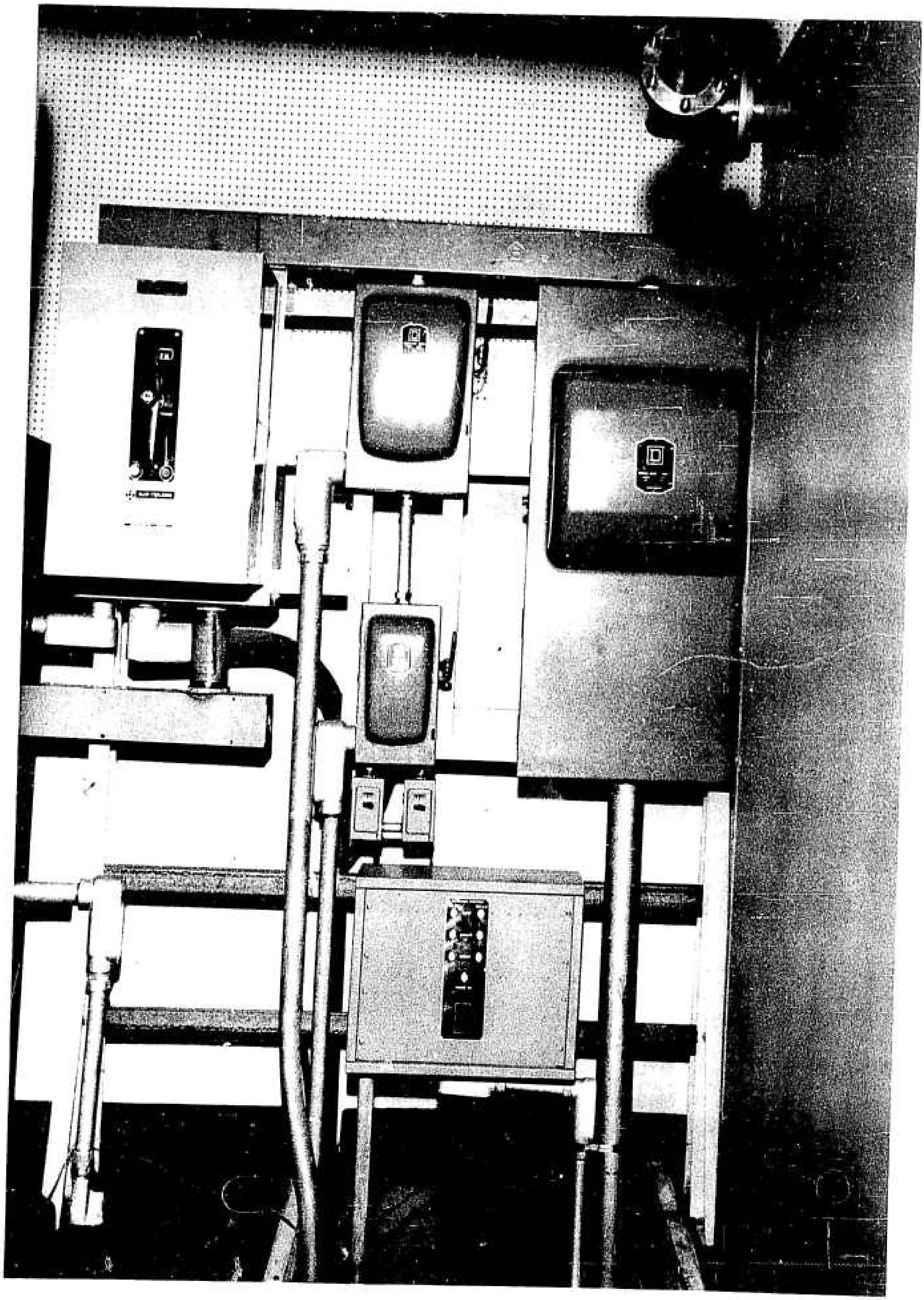


Figure 69. RF Switch Position Indicator, Wall Disconnect Switches and 40-Kw Amplifier Group Plate Circuit Breaker.

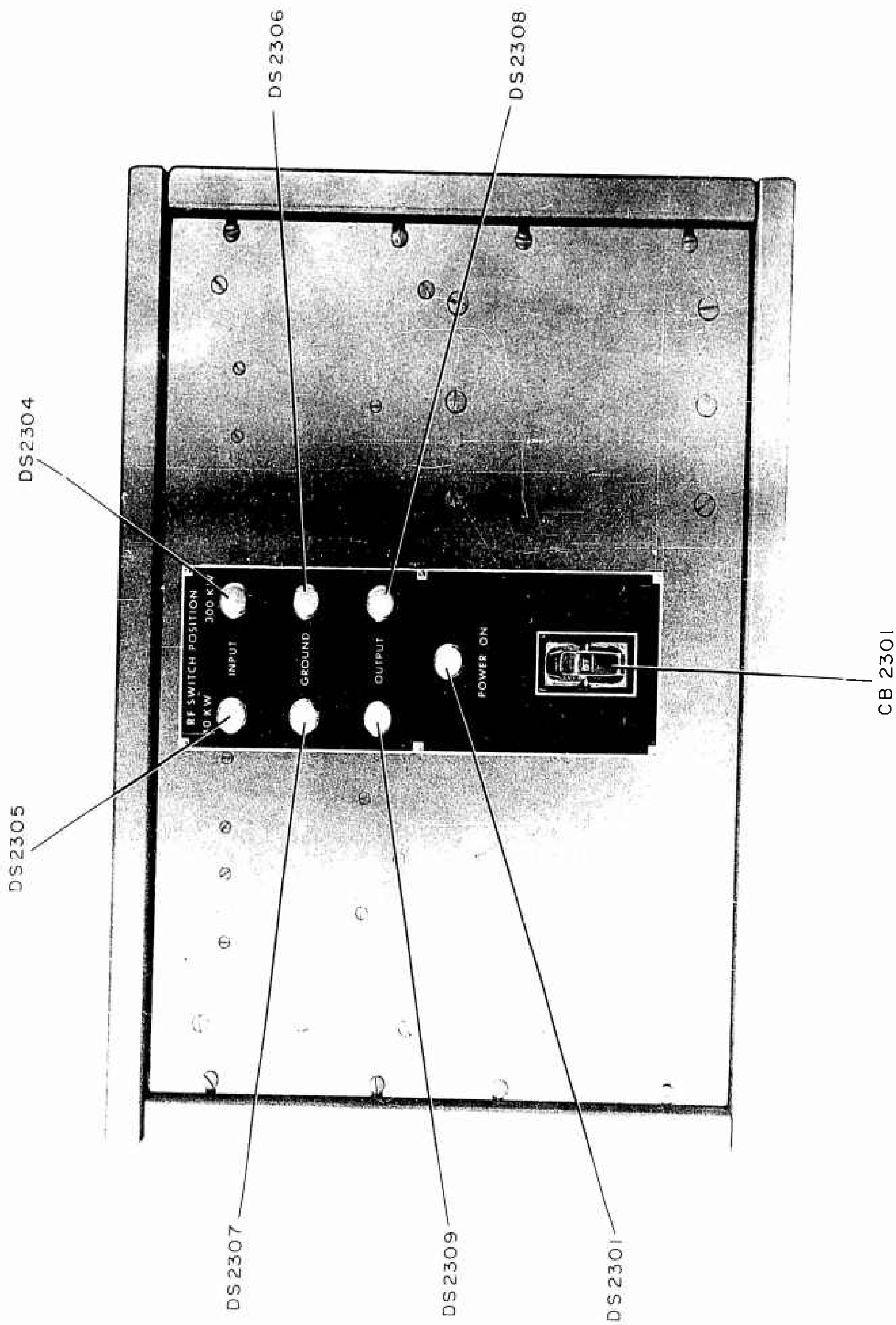


Figure 70. Switch Position Indicator Panel, Location of Controls and Indicators.

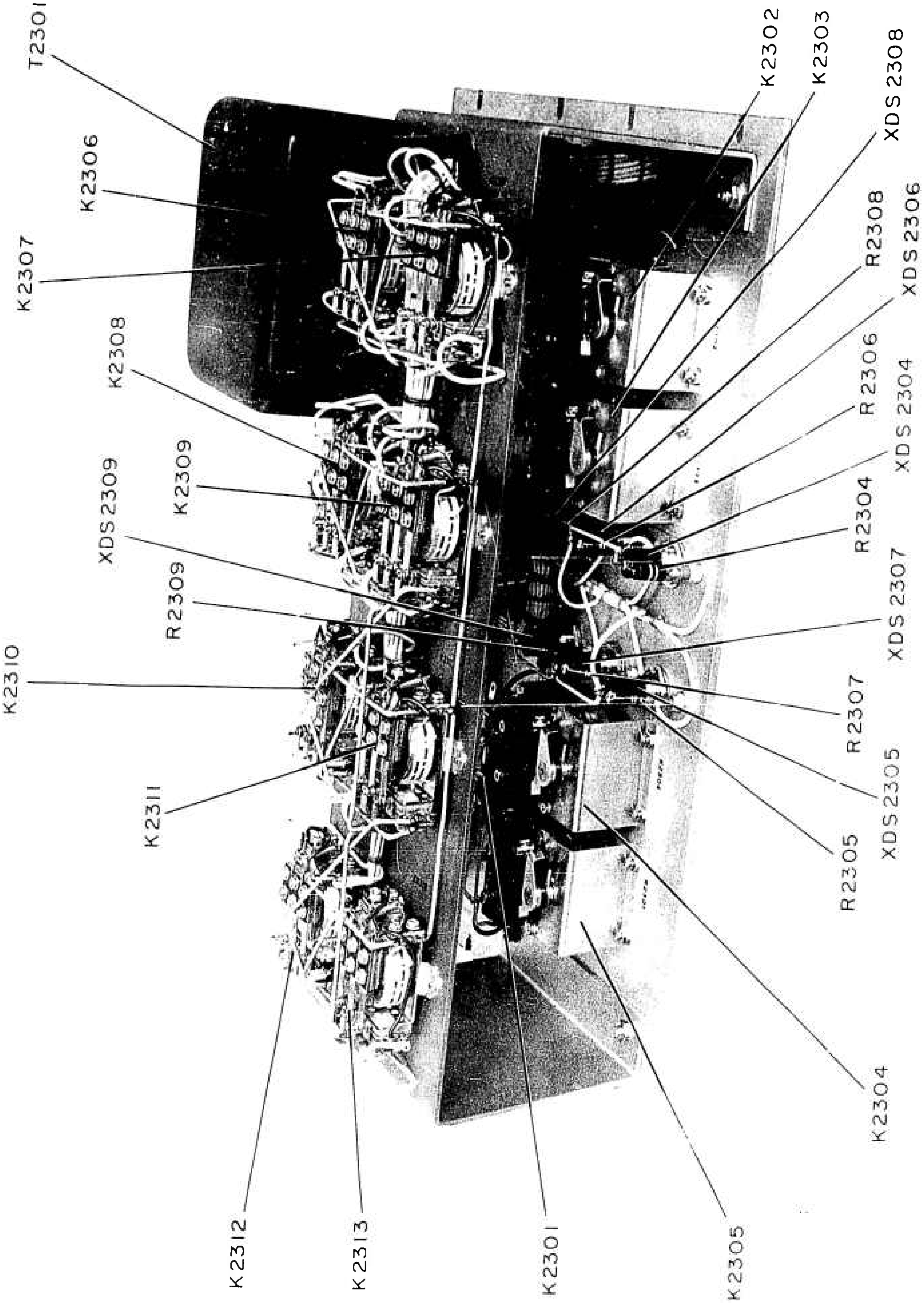


Figure 71. RF Switch Position Indicator Panel, Top View.

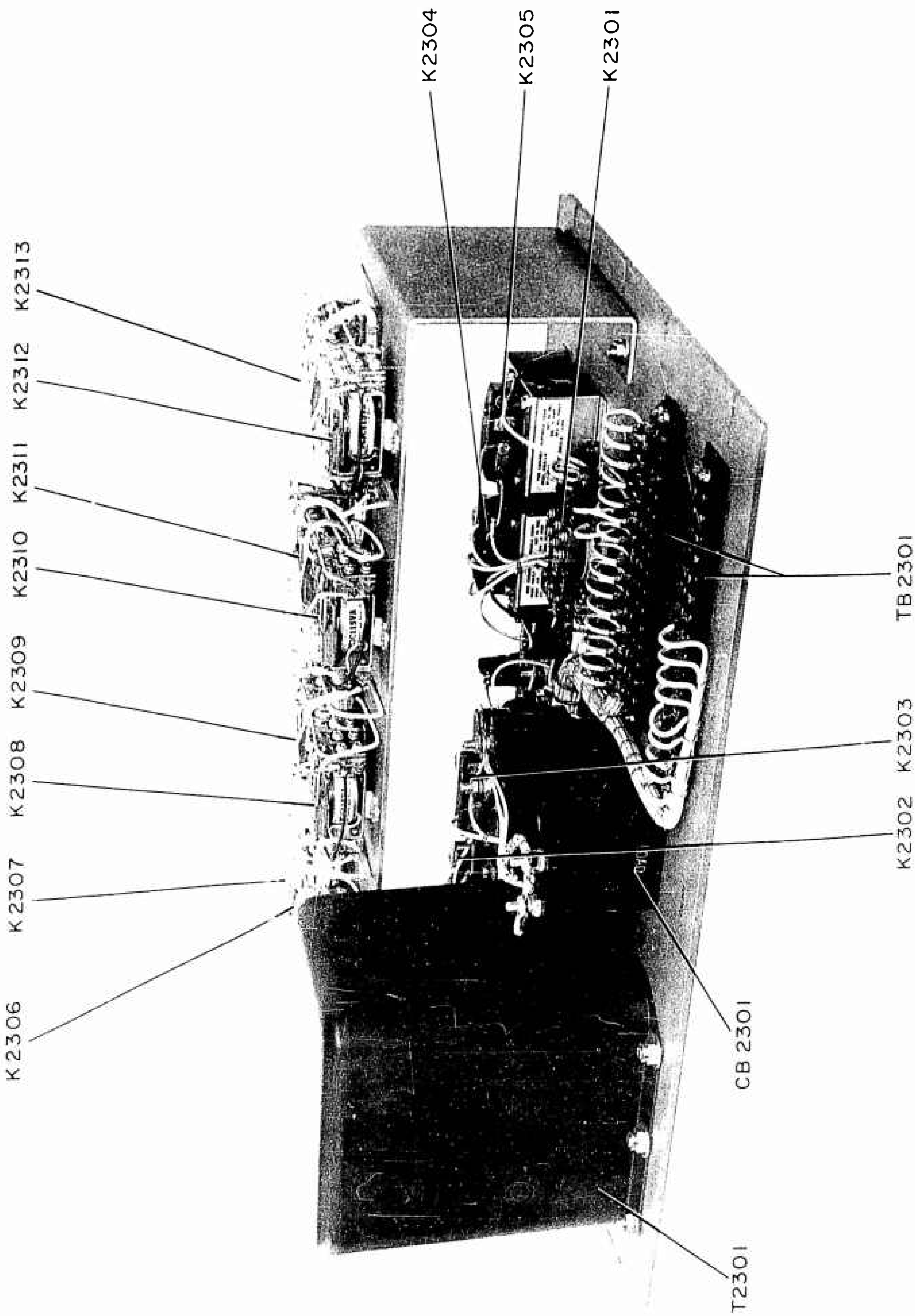


Figure 72. RF Switch Position Indicator Panel, Bottom View.

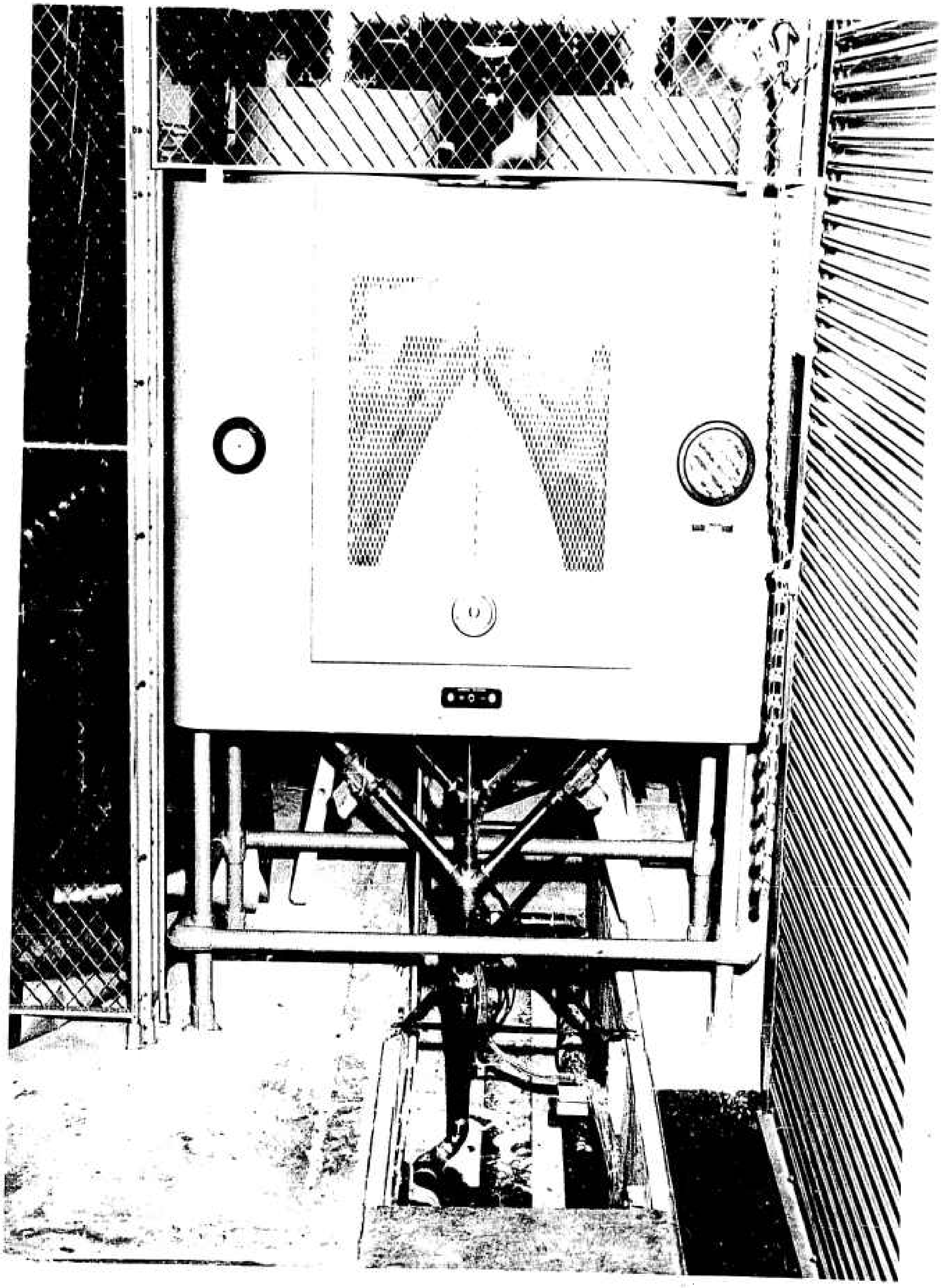


Figure 73. Dummy Load.

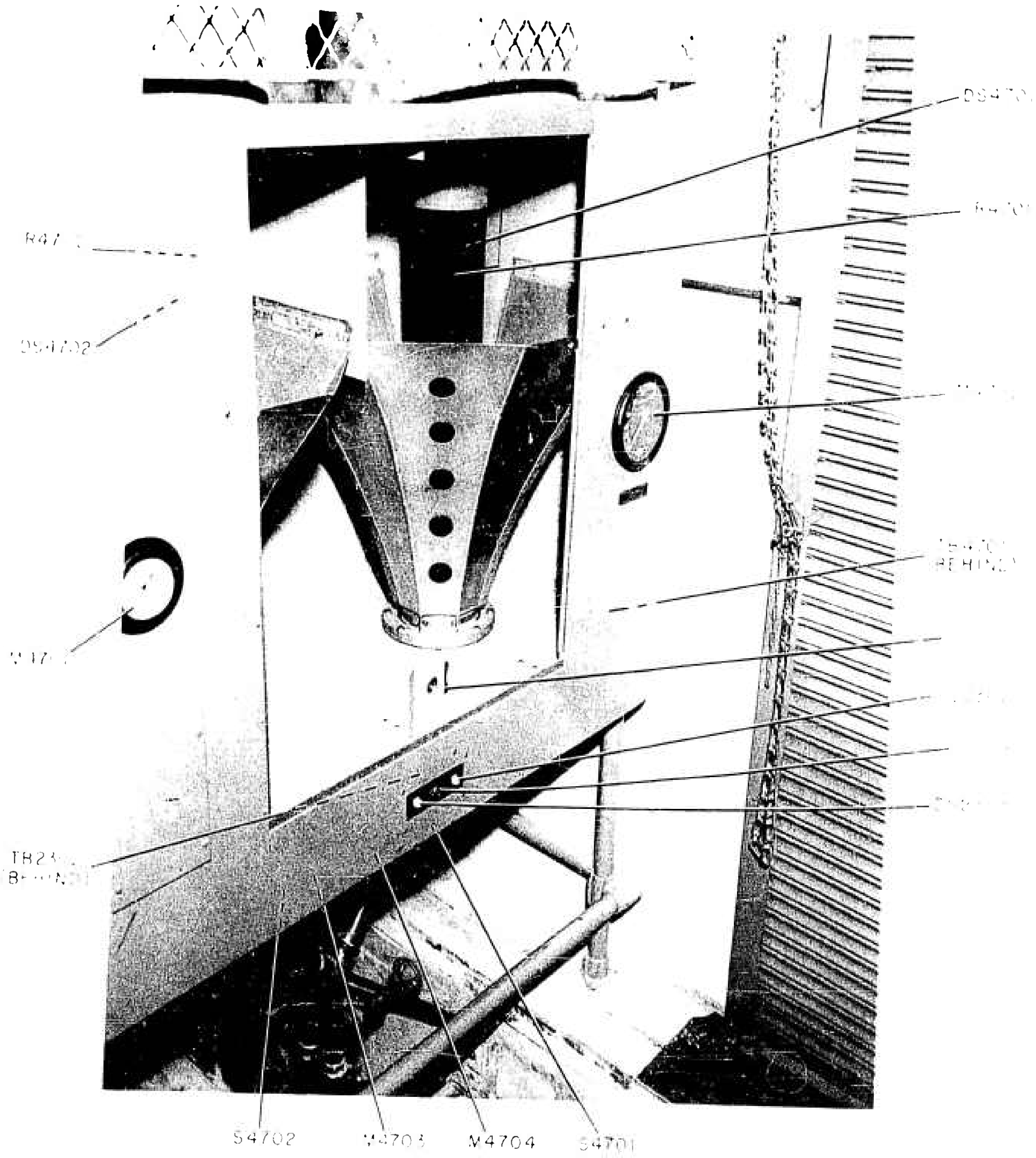


Figure 74. Dummy Load, Oblique View, Door Removed.

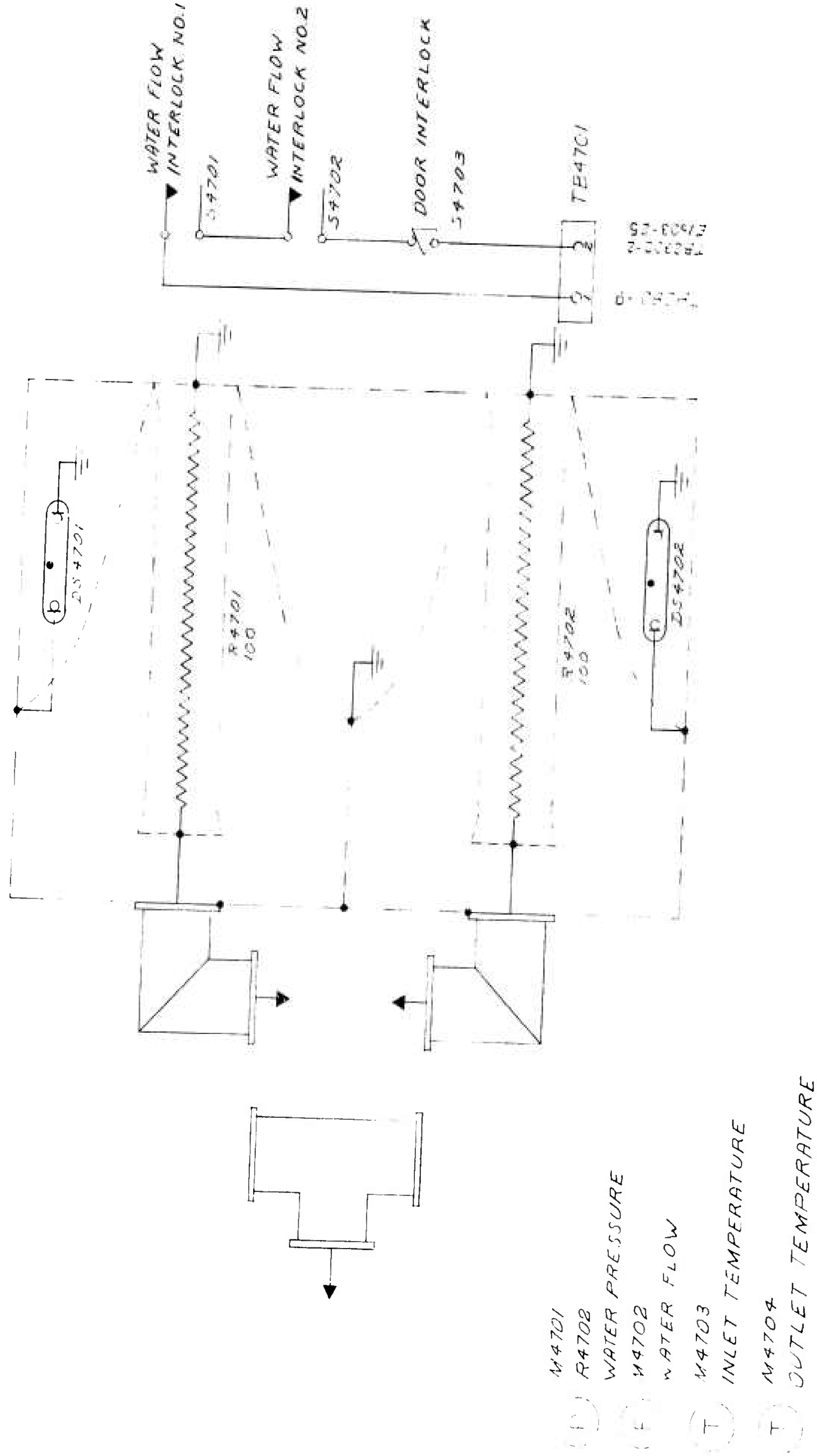


Figure 75. Schematic Diagram, Dummy Load.

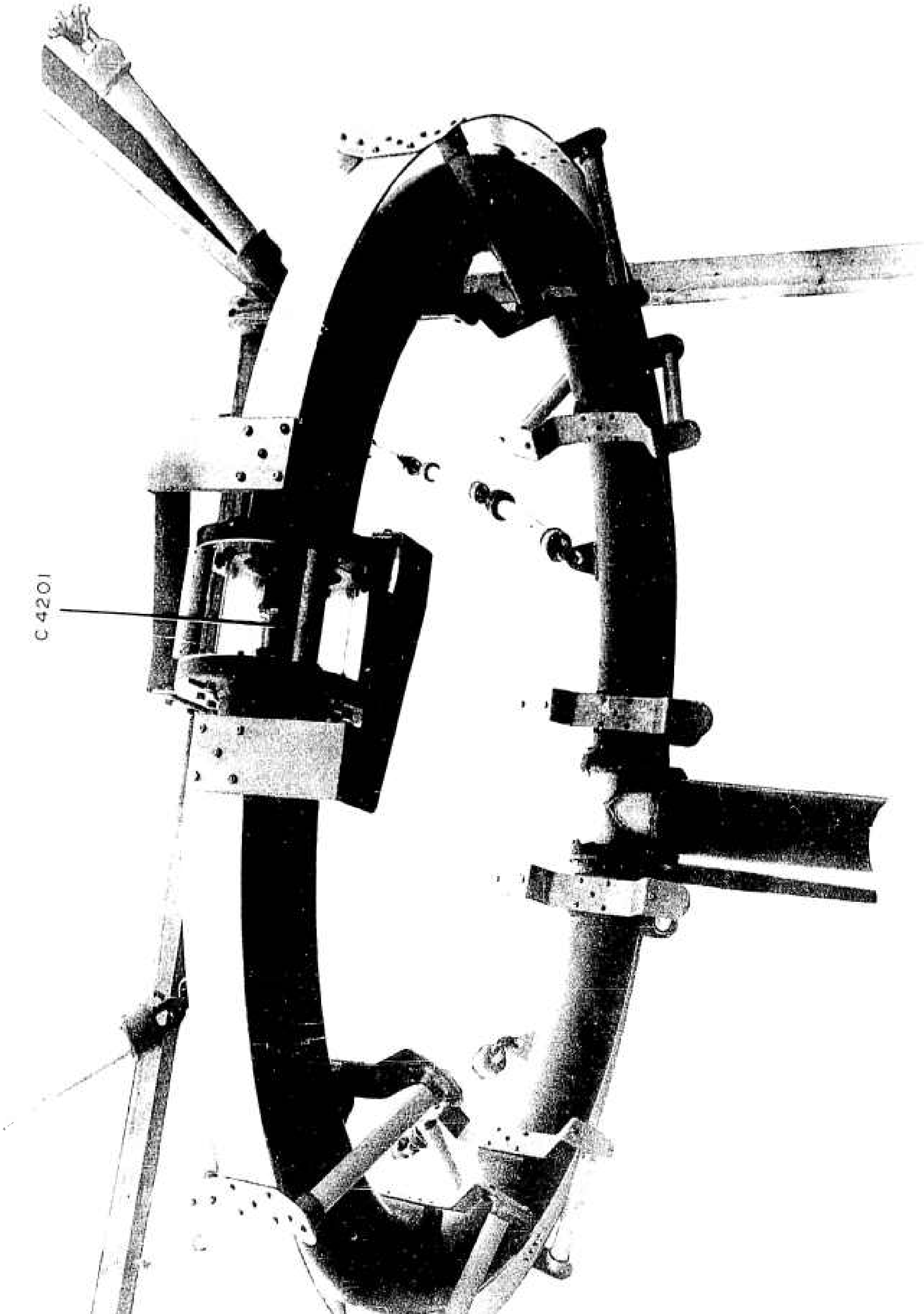


Figure 76. Balun.

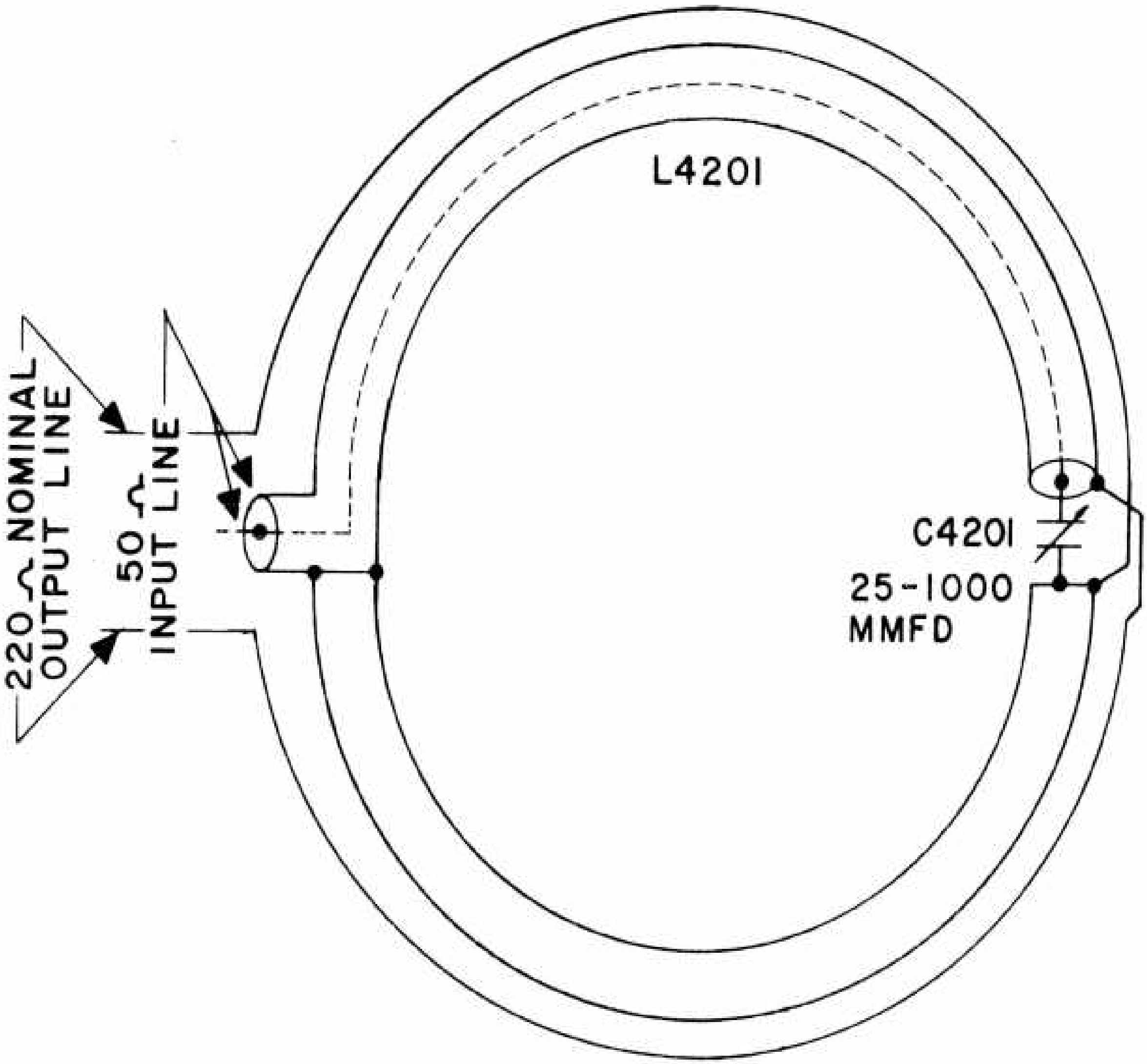


Figure 77. Schematic Diagram, Balun.

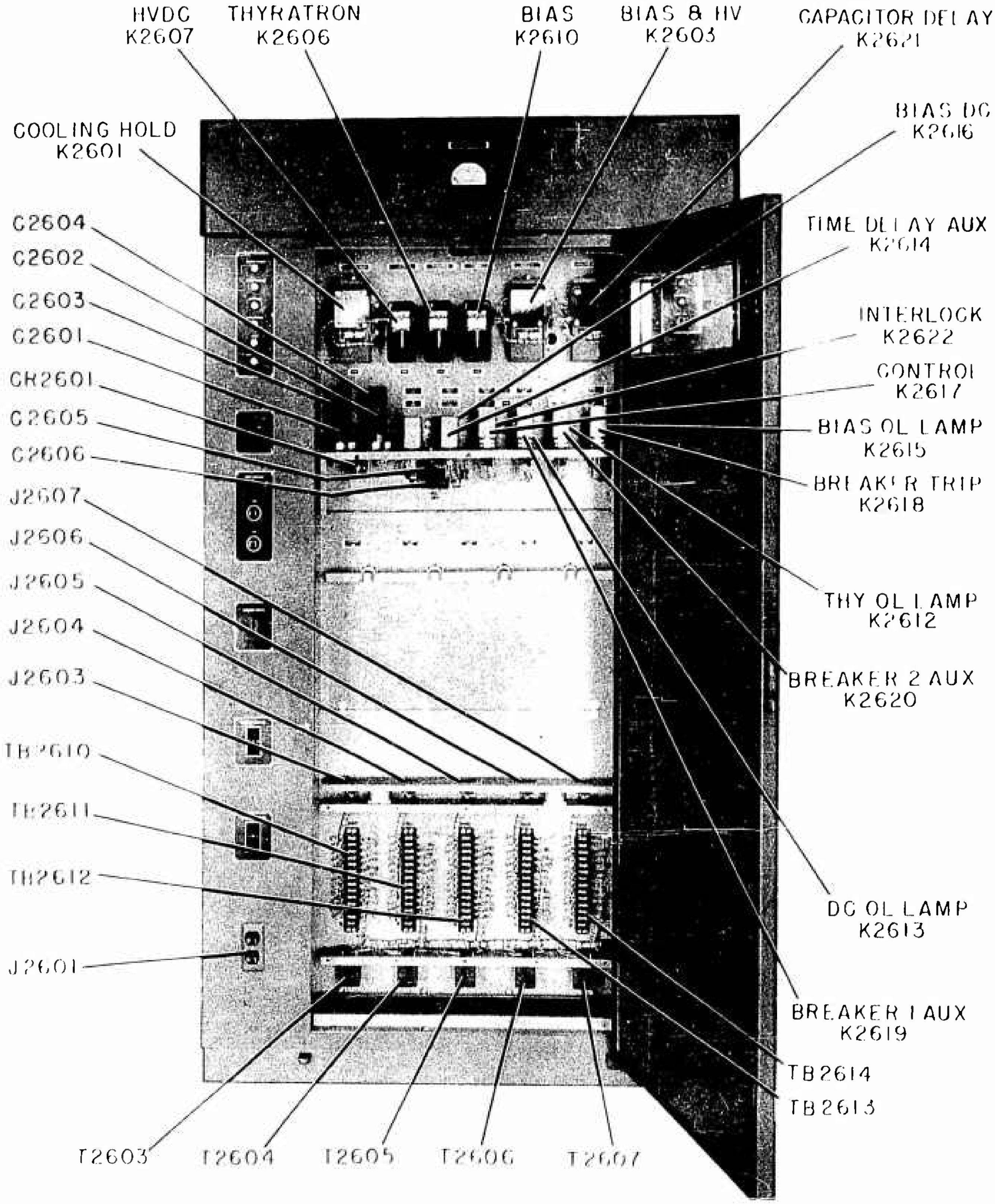


Figure 78. Control Unit, Front View, Door Open.

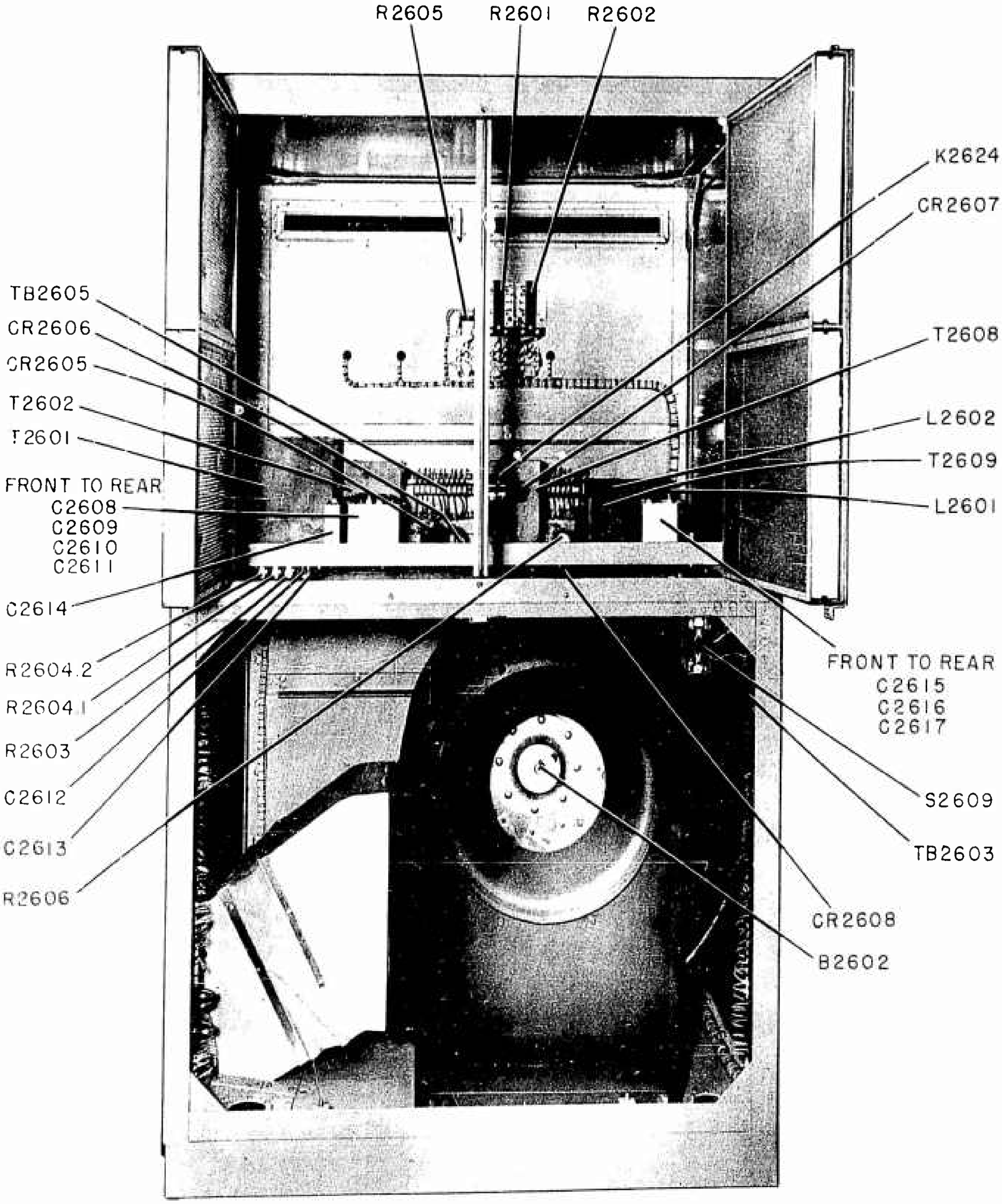


Figure 79. Control Unit, Rear View, Filters Swung Out and Panel Removed.

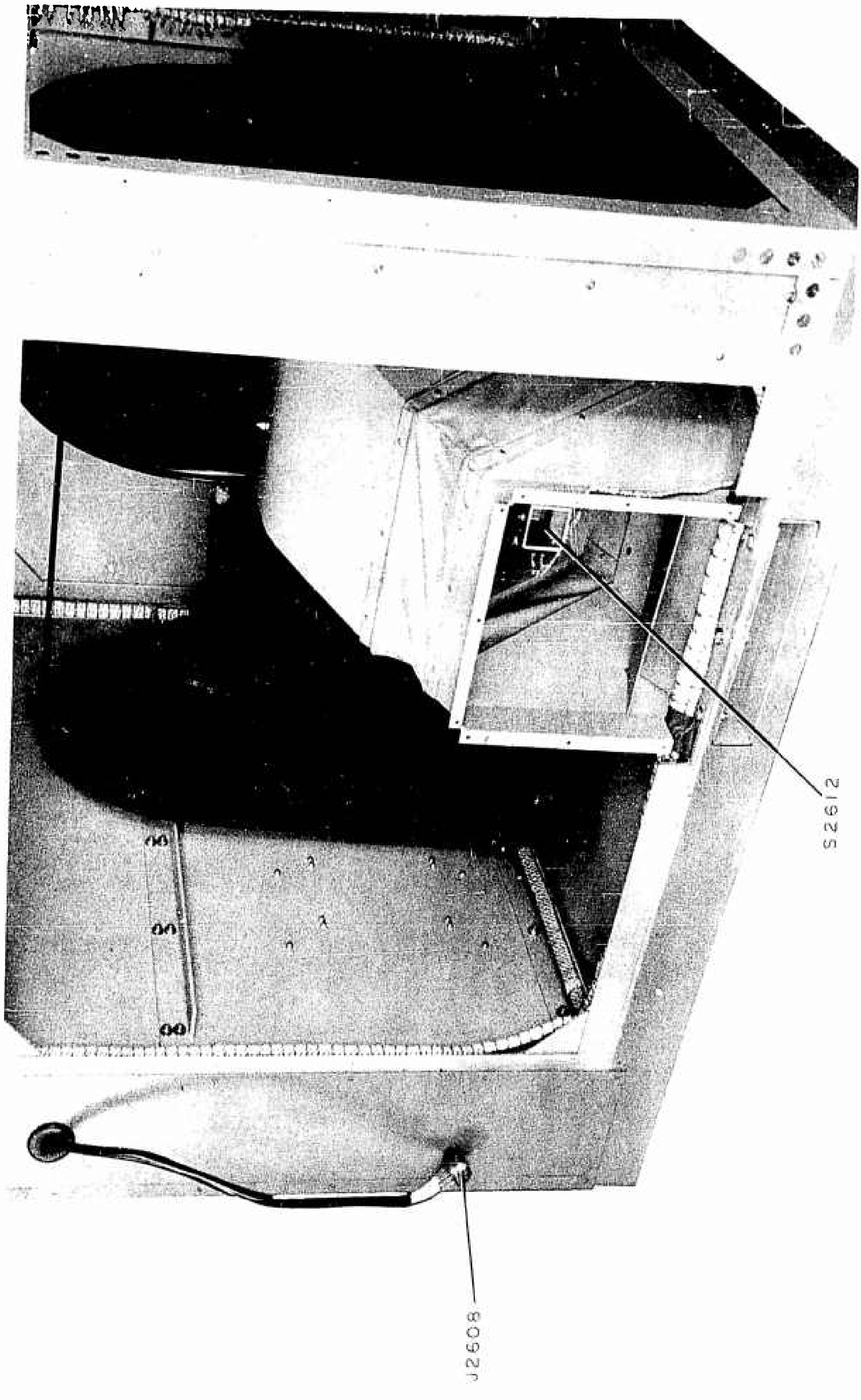
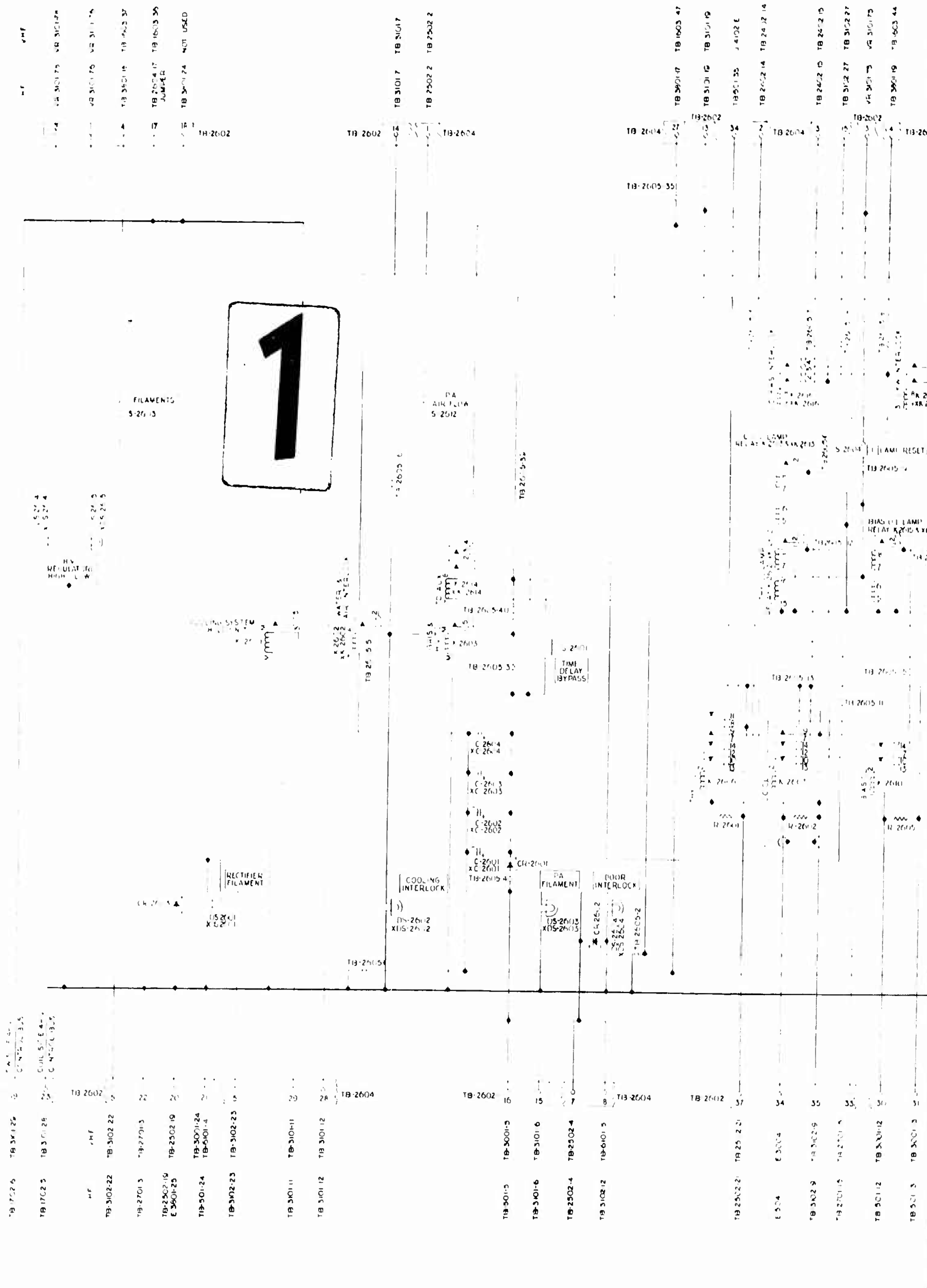


Figure 80. Control Unit, Side View, Skin Removed.


1
TB-2602
TB-2604
FILAMENTS
PA AIR FLOW
S-2612
TIME DELAY BYPASS
RECTIFIER FILAMENT
COOLING INTERLOCK
PA FILAMENT
DOOR INTERLOCK
NOT USED

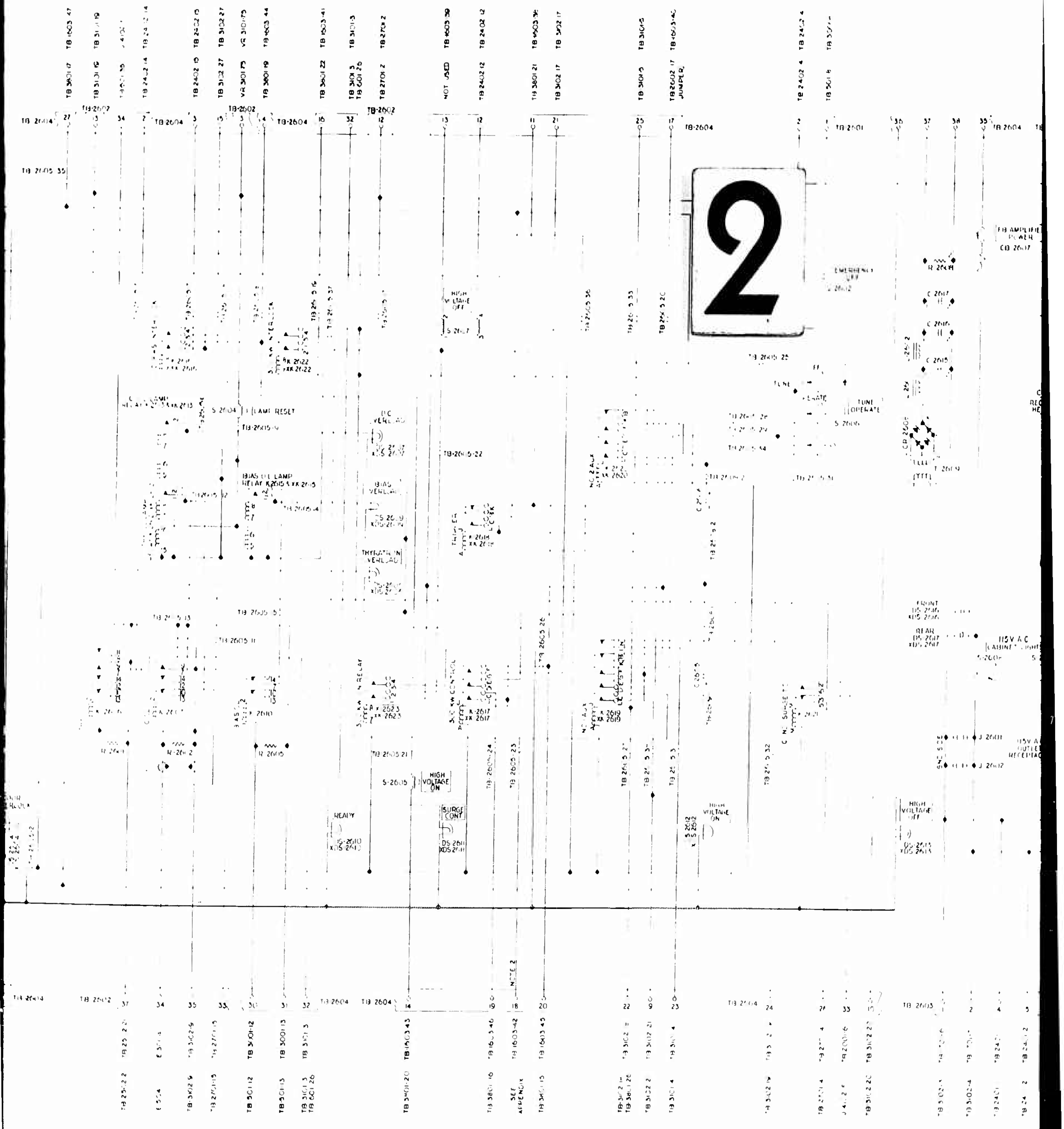
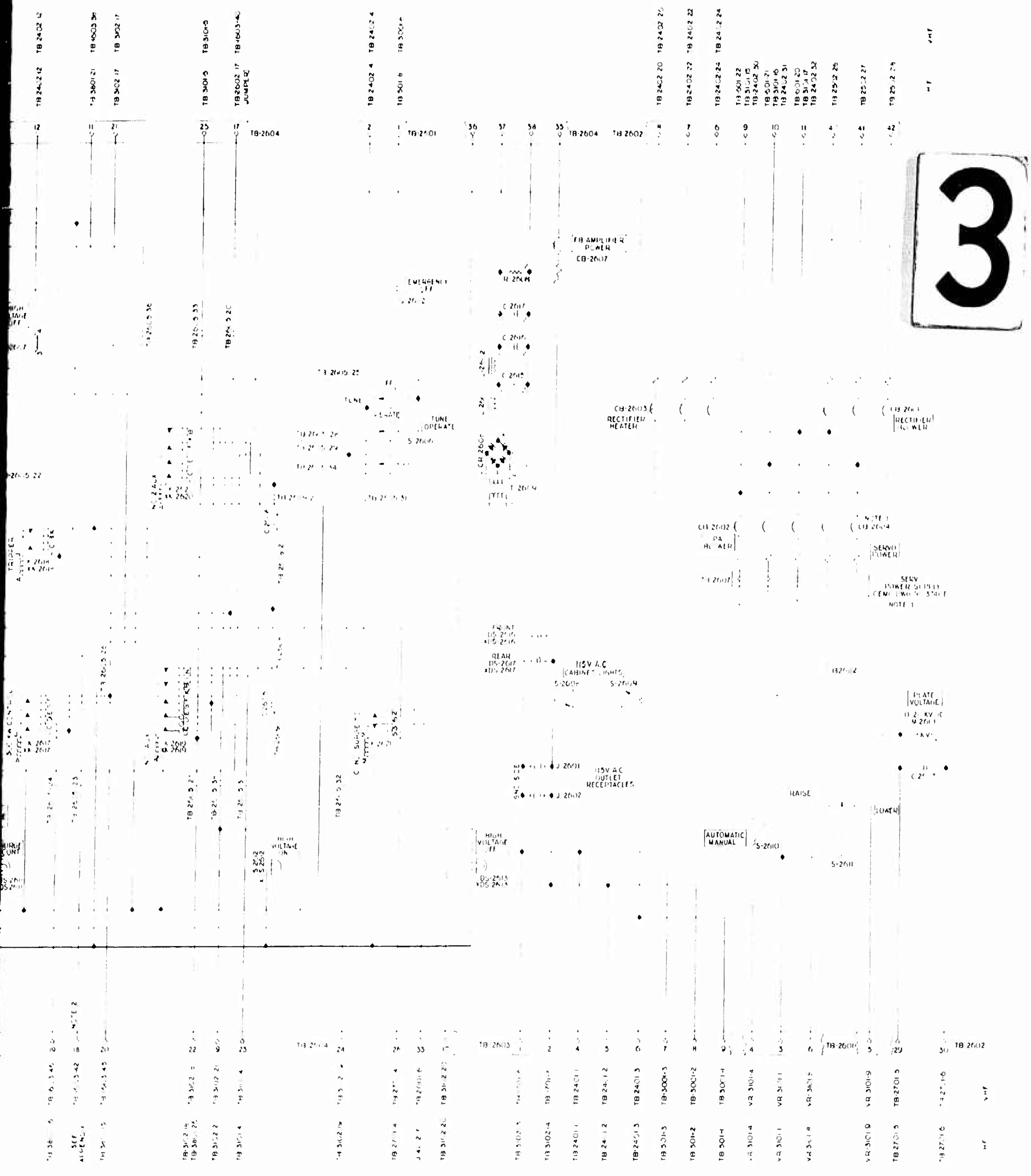


Figure 81. Schematic Diagra
Inte

NOTE 1 USE FOR HF ONLY
NOTE 2 DISCONNECT WIRE FOR HF



NOTE 1 USE FOR HF ONLY
NOTE 2 DISCONNECT WIRE FOR HF

Figure 81. Schematic Diagram, Control Unit (except Tuning Servo Interconnections).

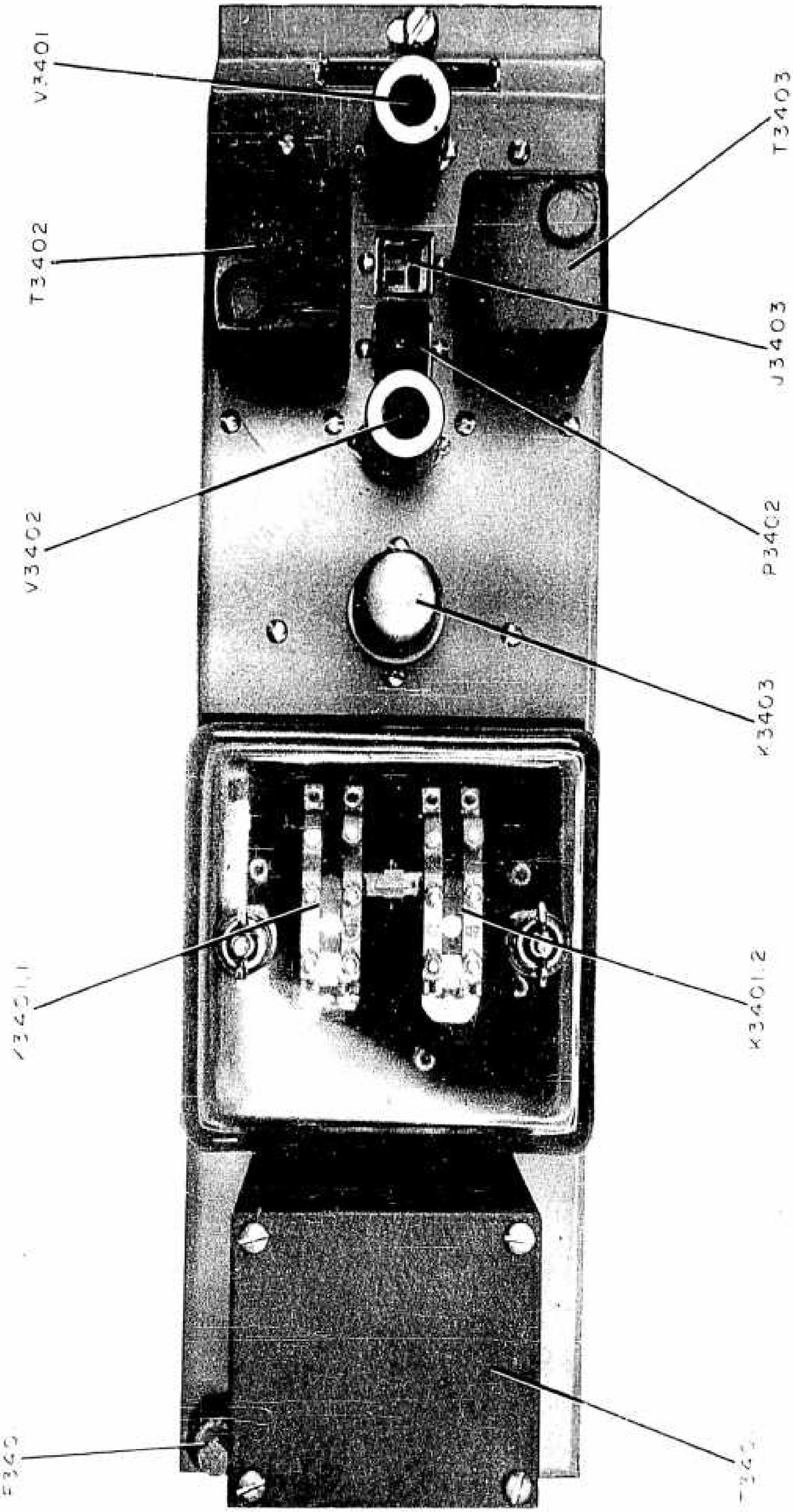


Figure 82. Tuning Servo Amplifier Z2601 through Z2605 or Z607, Front View

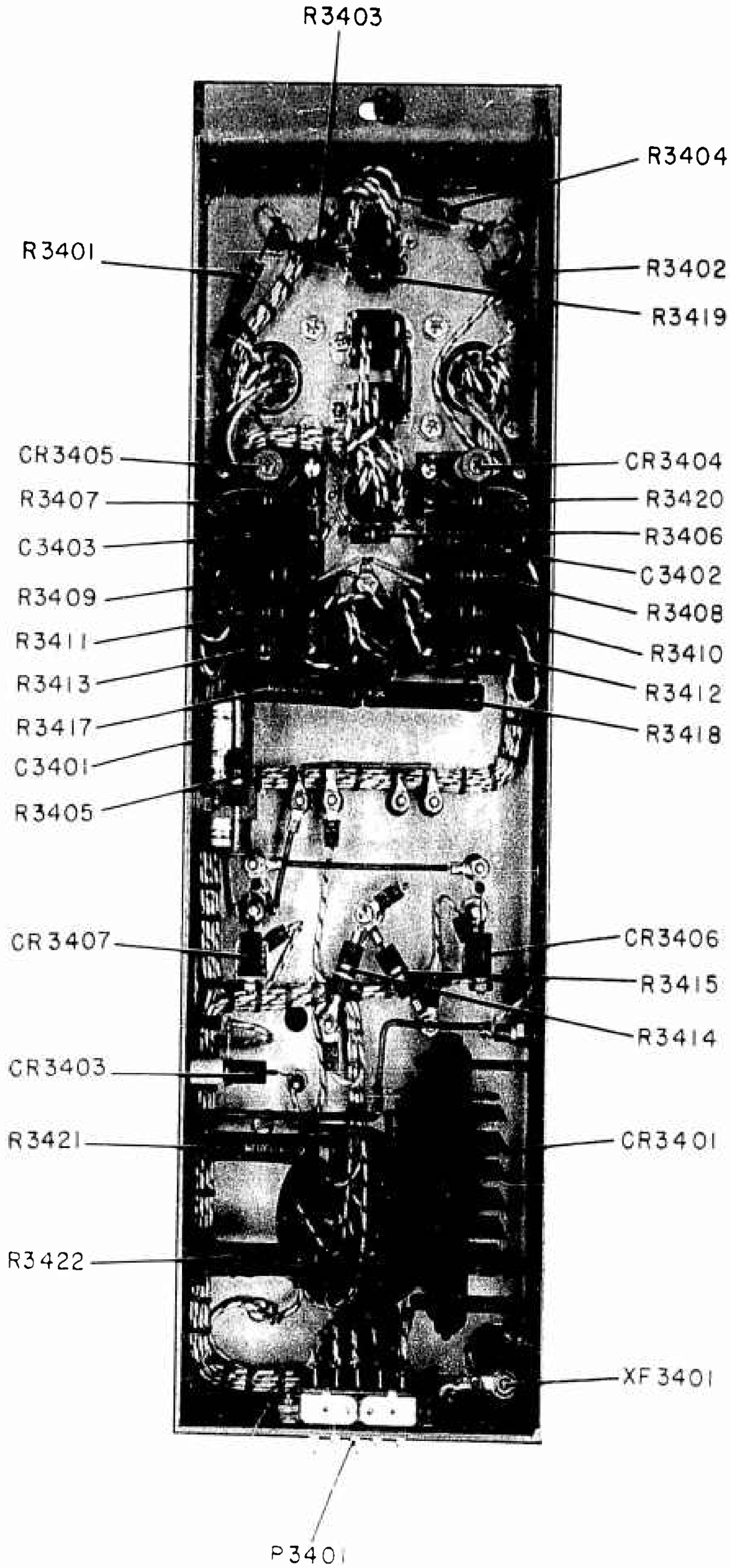


Figure 83. Tuning Servo Amplifier Z2601 through Z2605 or Z607, Rear View.

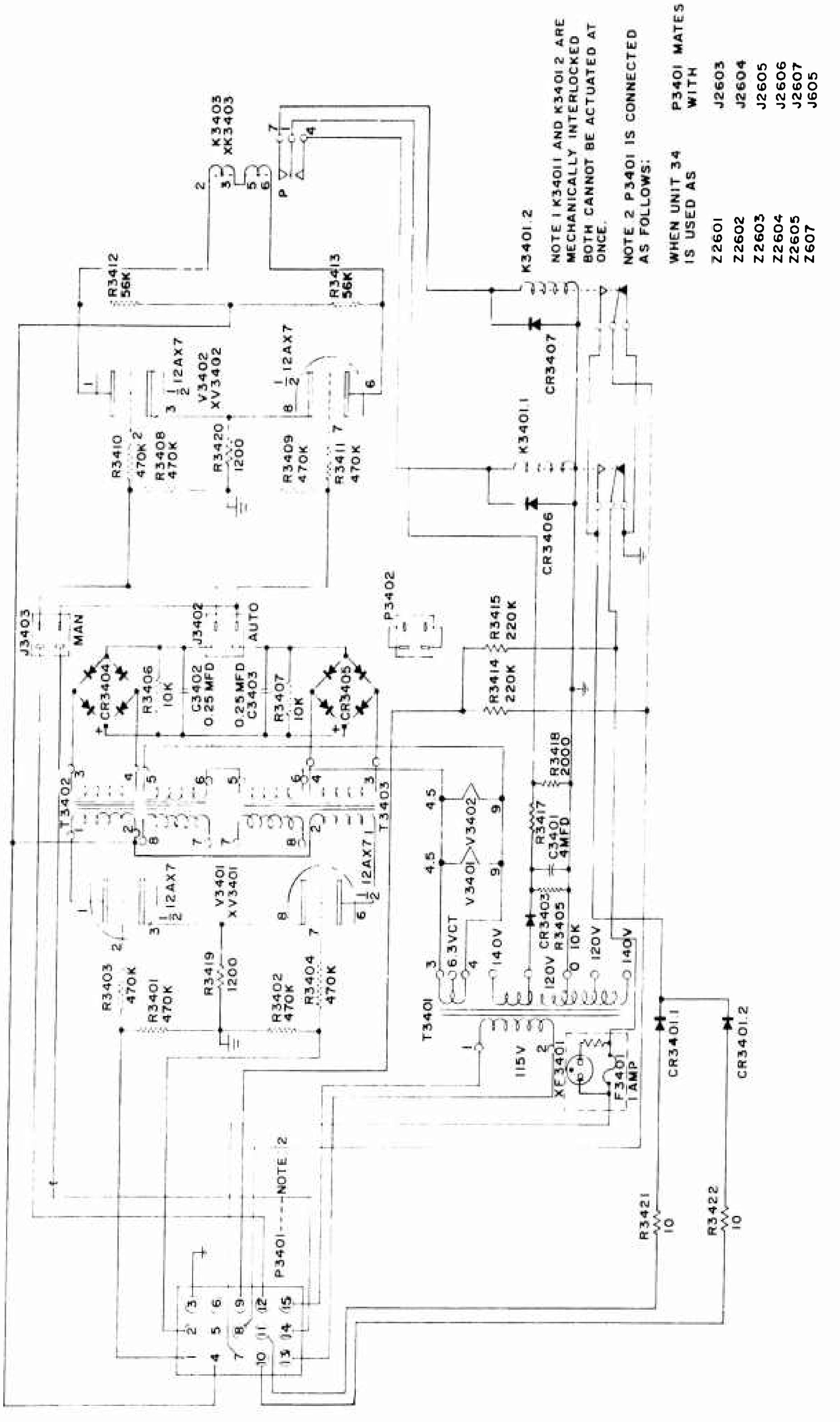
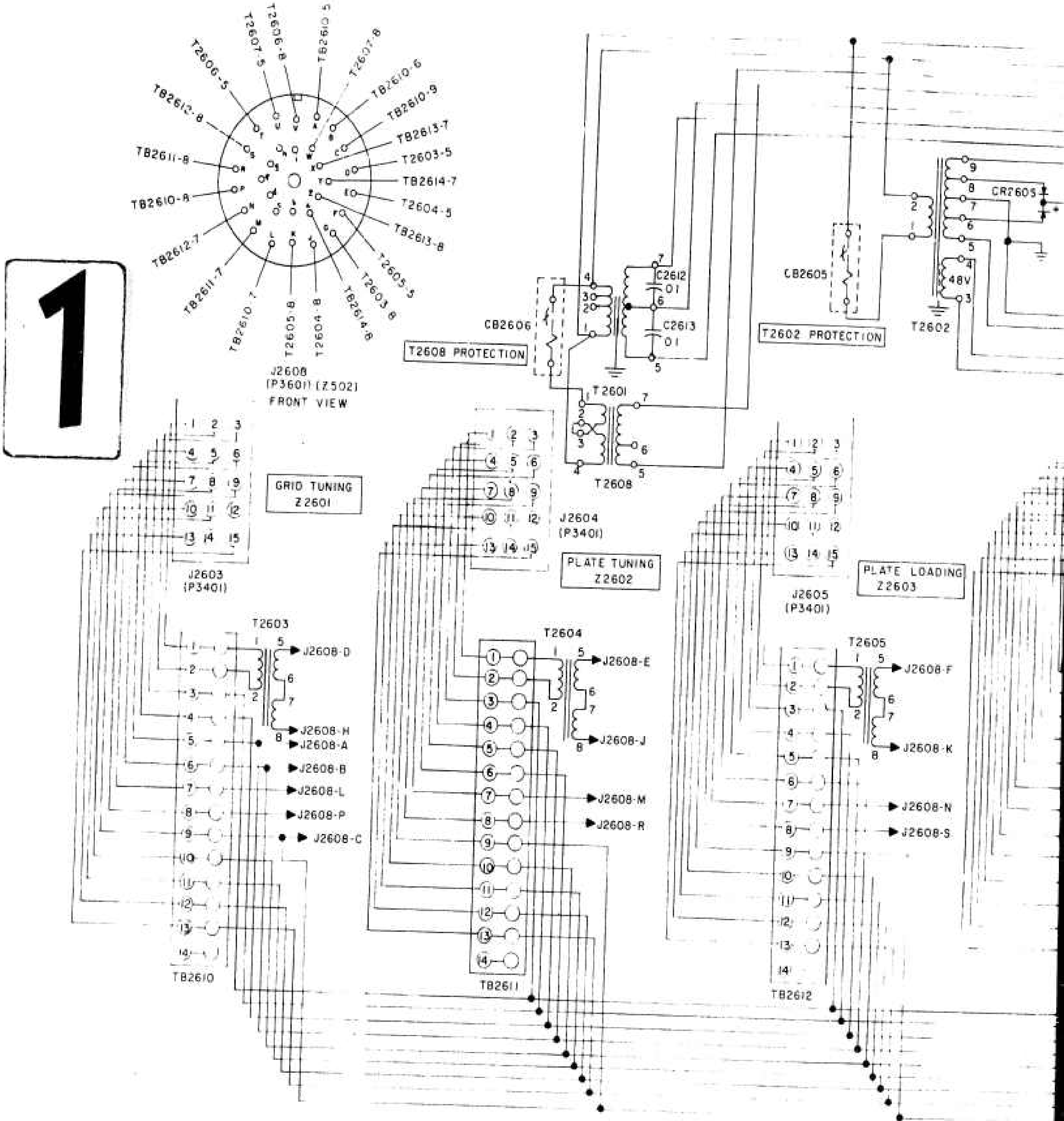
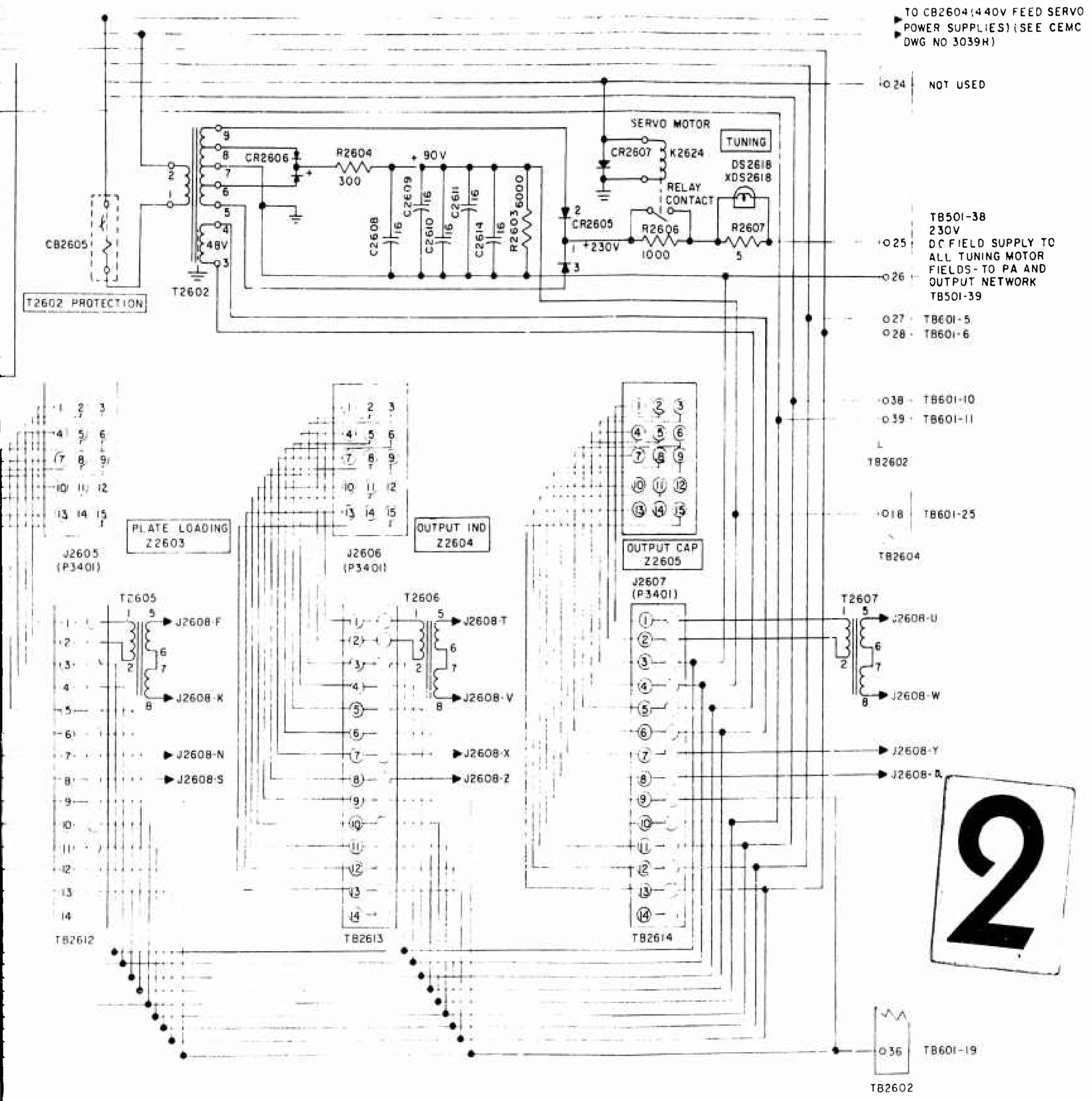


Figure 84. Schematic Diagram, Tuning Servo Amplifier Z2601 through Z2605 or Z607.


1
J2608
(P3601) (Z502)
FRONT VIEW
T2606-5
T2607-5
T2606-8
TB2610-5
T2607-8
TB2610-6
TB2610-9
TB2613-7
T2603-5
TB2614-7
T2604-5
TB2613-8
T2605-5
T2603-8
TB2614-8
T2604-8
T2605-8
TB2610-7
TB2611-7
TB2612-7
TB2610-8
TB2611-8
TB2612-8
CB2606
T2608 PROTECTION
C2612
.01
C2613
.01
T2601
T2608
CB2605
T2602 PROTECTION
T2602
CR2605
48V
GRID TUNING
Z2601
J2603
(P3401)
J2604
(P3401)
PLATE TUNING
Z2602
J2605
(P3401)
PLATE LOADING
Z2603
T2603
J2608-D
J2608-H
J2608-A
J2608-B
J2608-L
J2608-P
J2608-C
TB2610
T2604
J2608-E
J2608-J
J2608-M
J2608-R
TB2611
T2605
J2608-F
J2608-K
J2608-N
J2608-S
TB2612



FOR 300 KW CONTROL
SEE DWG NO 3039-R

Figure 85. Schematic Diagram, Servo Power Supply and Interconnections.

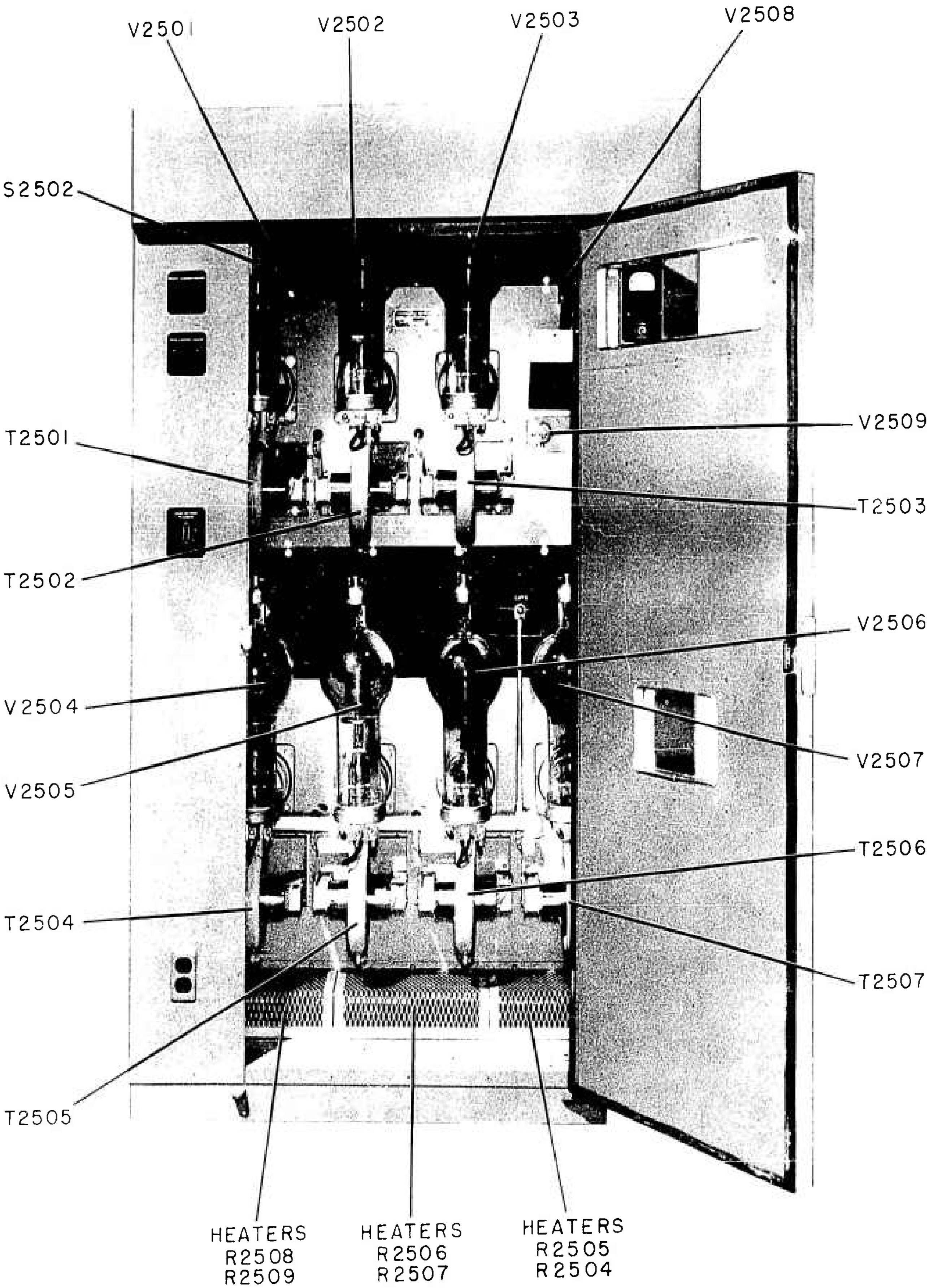


Figure 86. Rectifier Unit No. 1, Front View, Door Open.

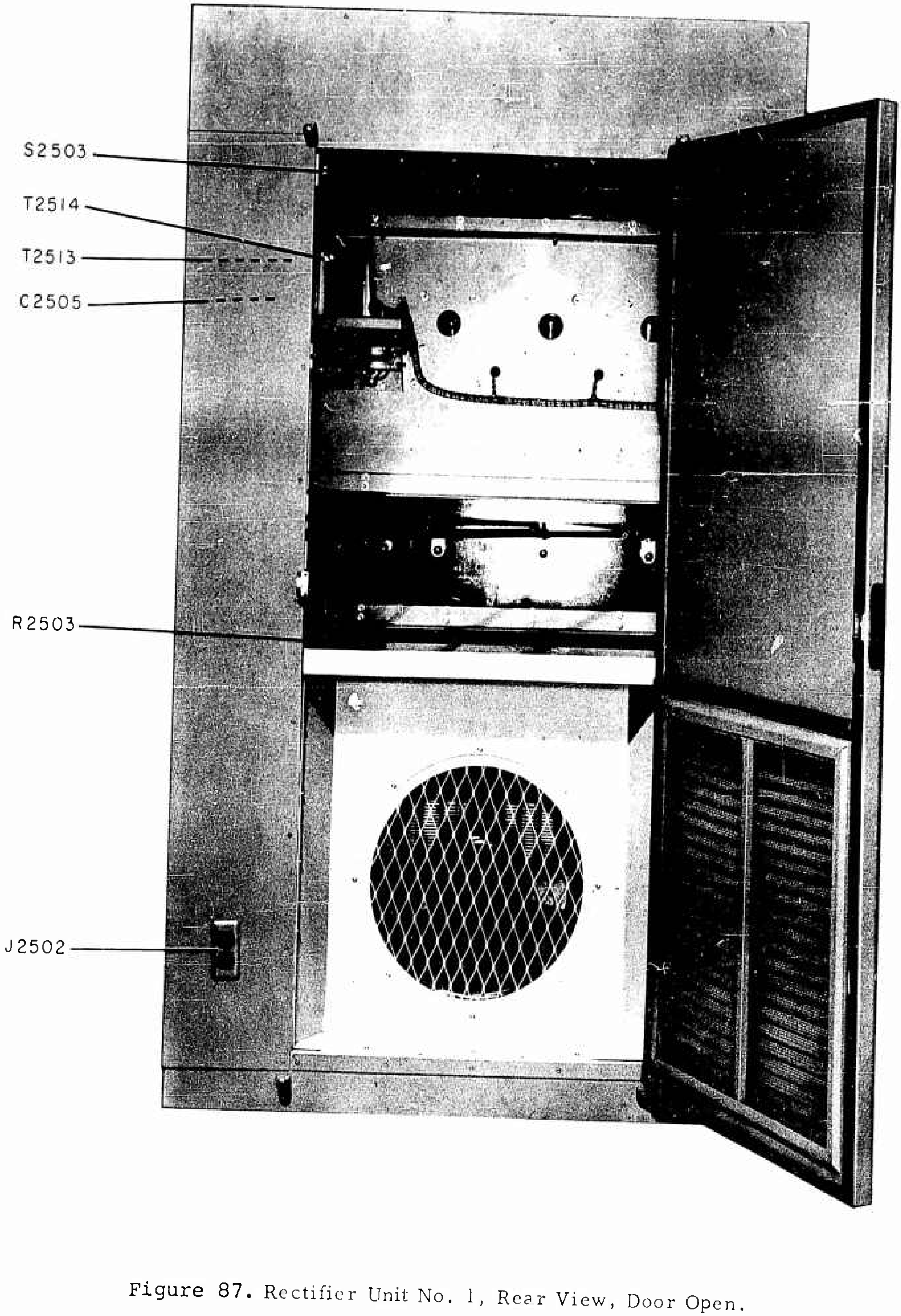


Figure 87. Rectifier Unit No. 1, Rear View, Door Open.

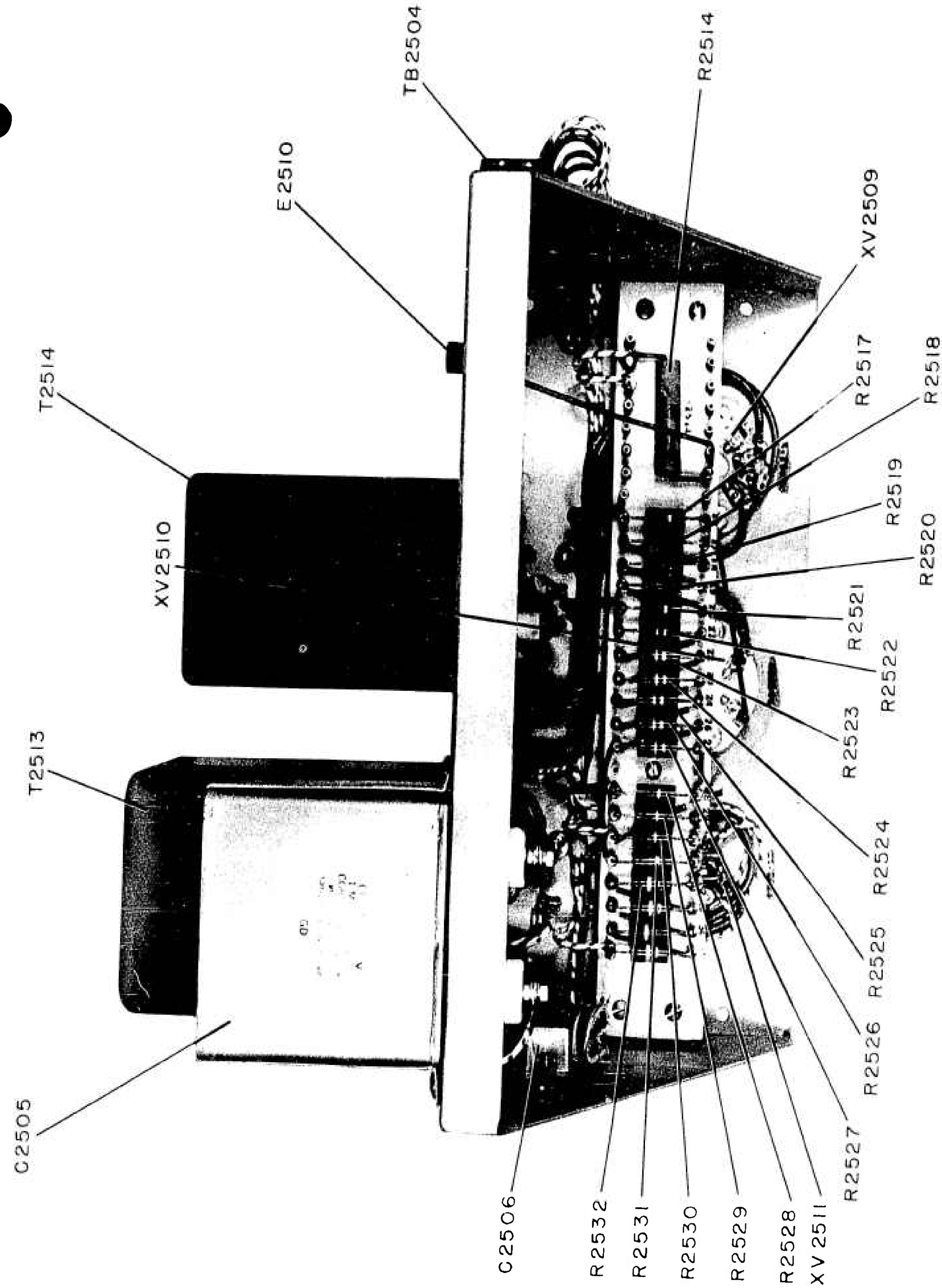


Figure 88. Fault Amplifier, Rear View.

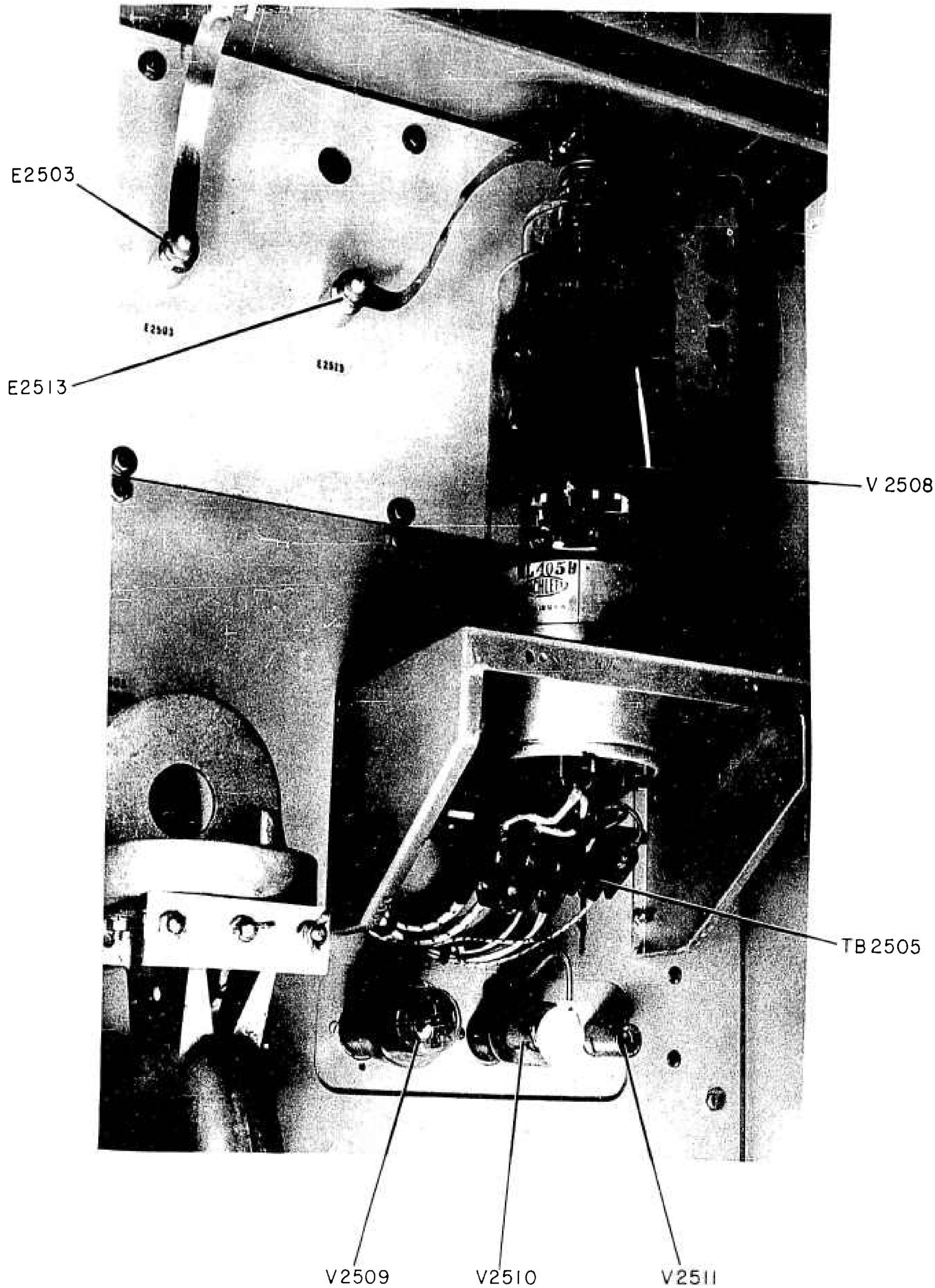


Figure 89. Fault Amplifier, Front View.

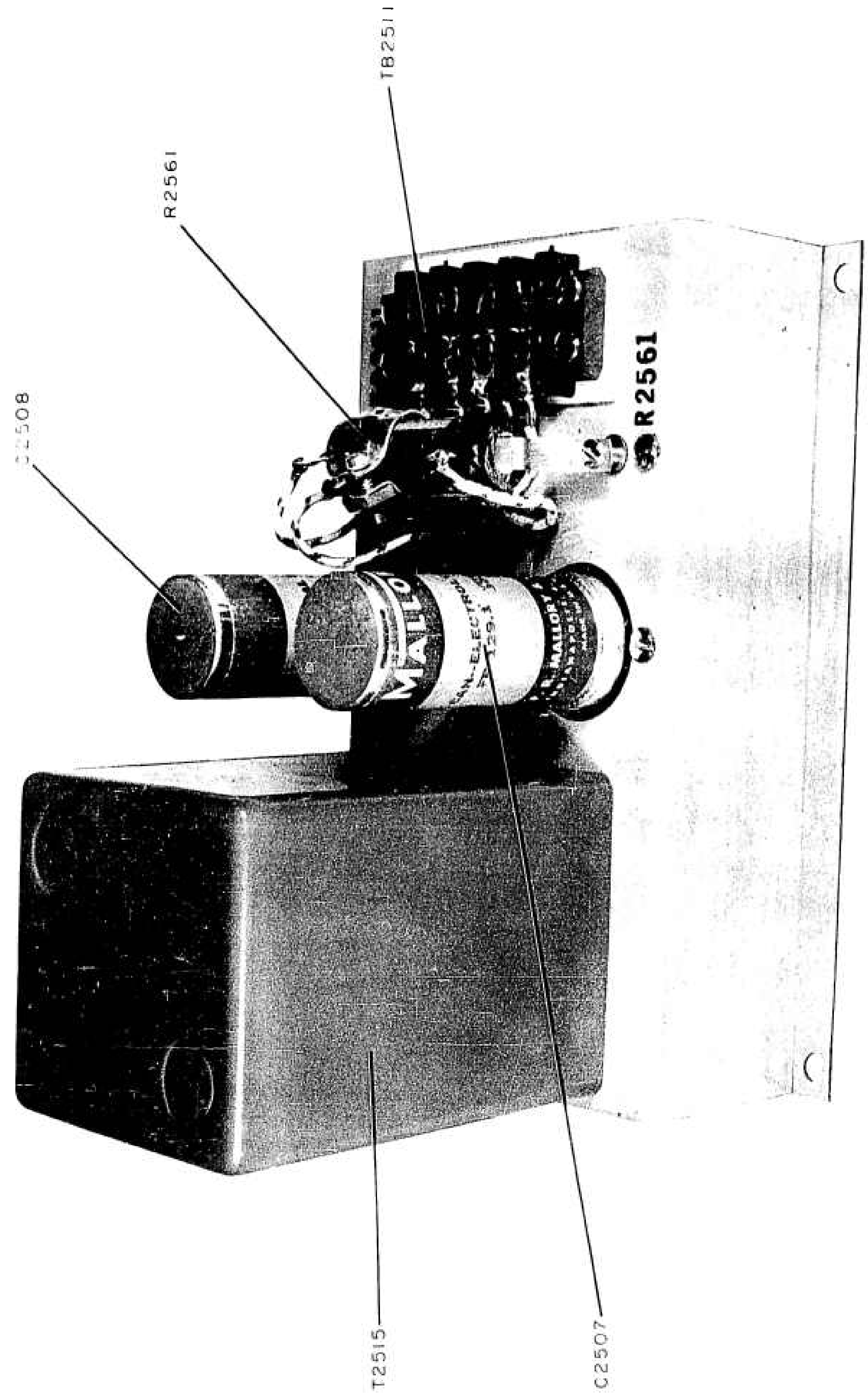


Figure 90. Fault Amplifier Bias Supply, Oblique View.

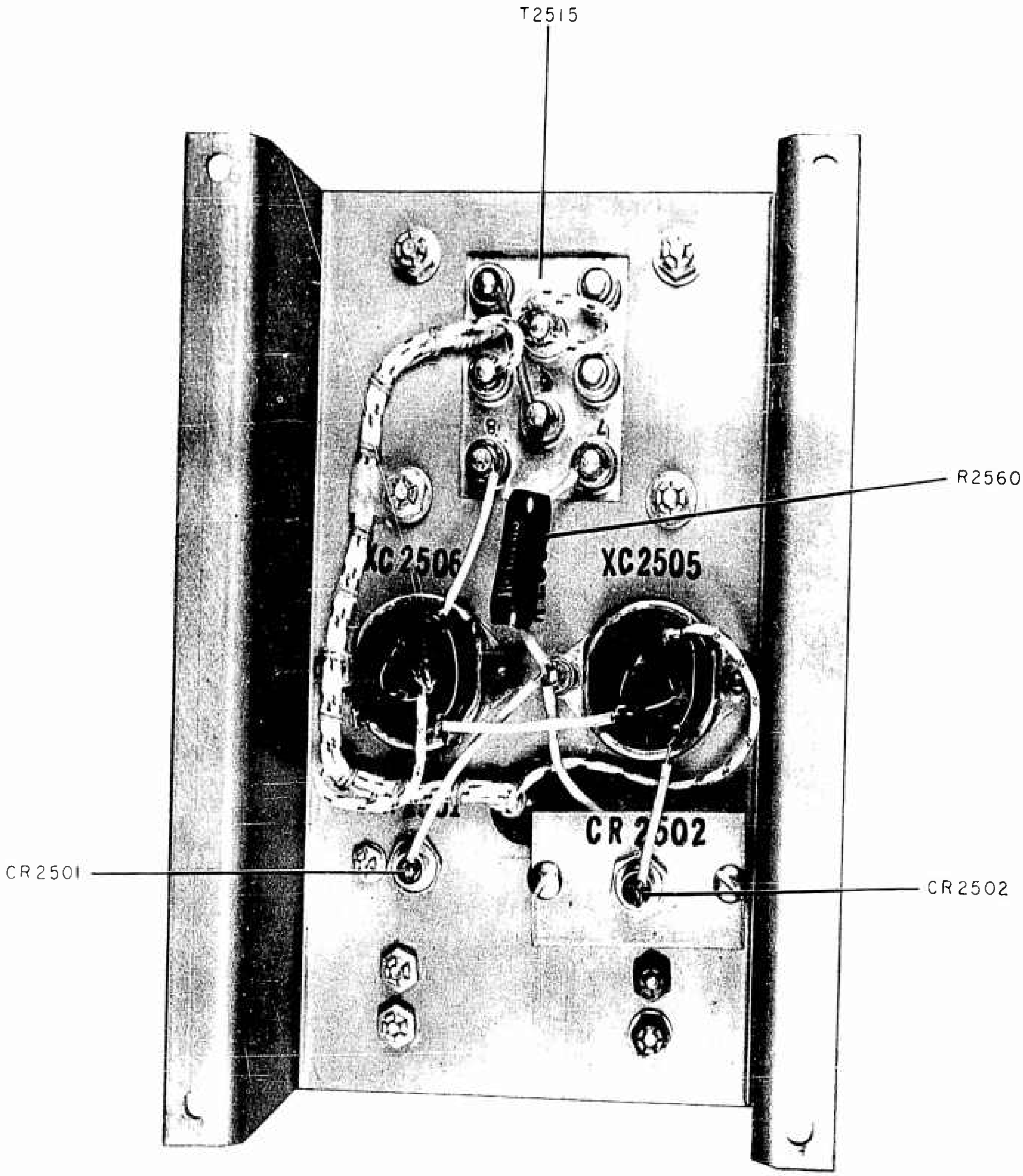


Figure 91. Fault Amplifier Bias Supply, Bottom View.

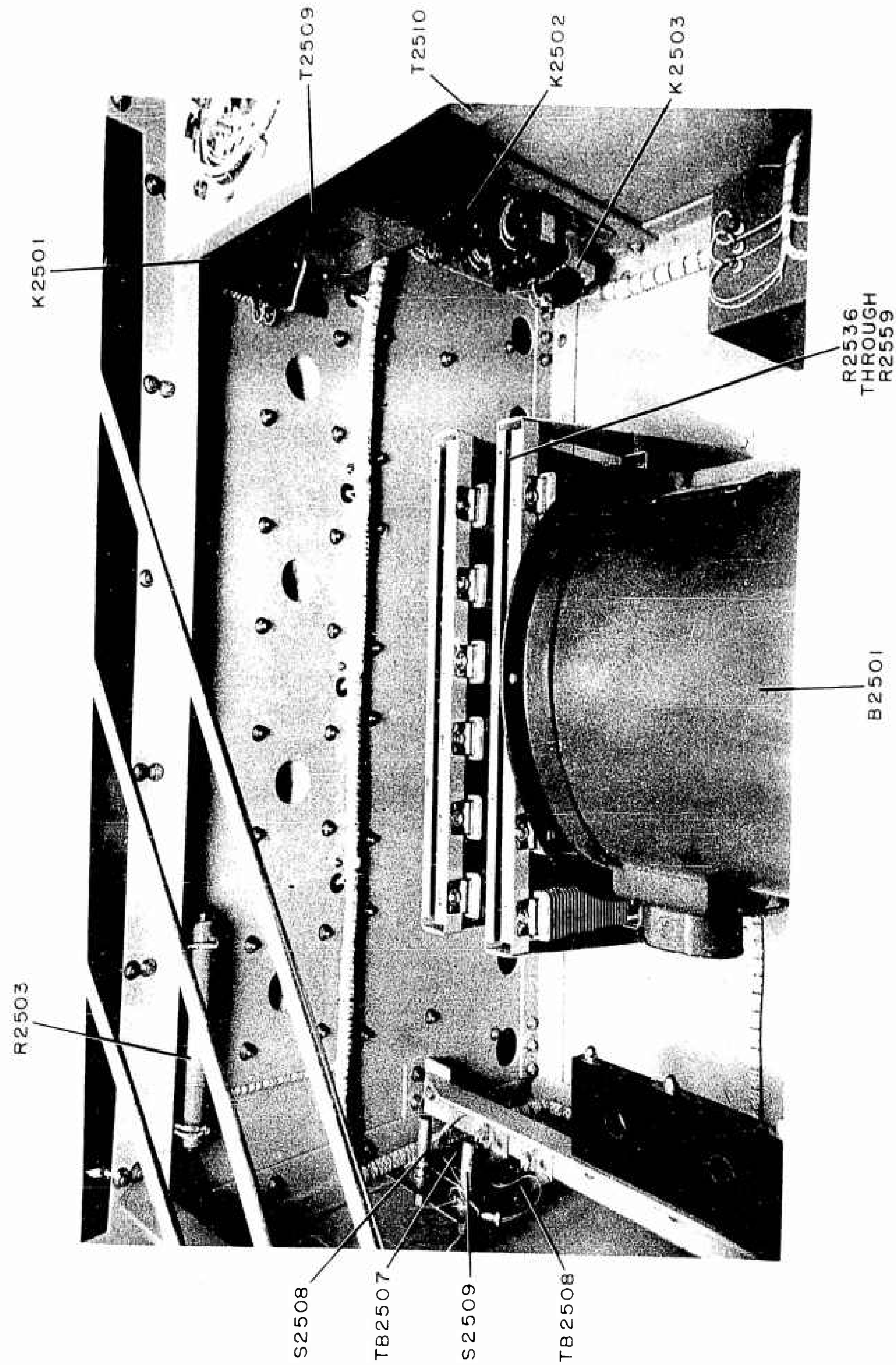
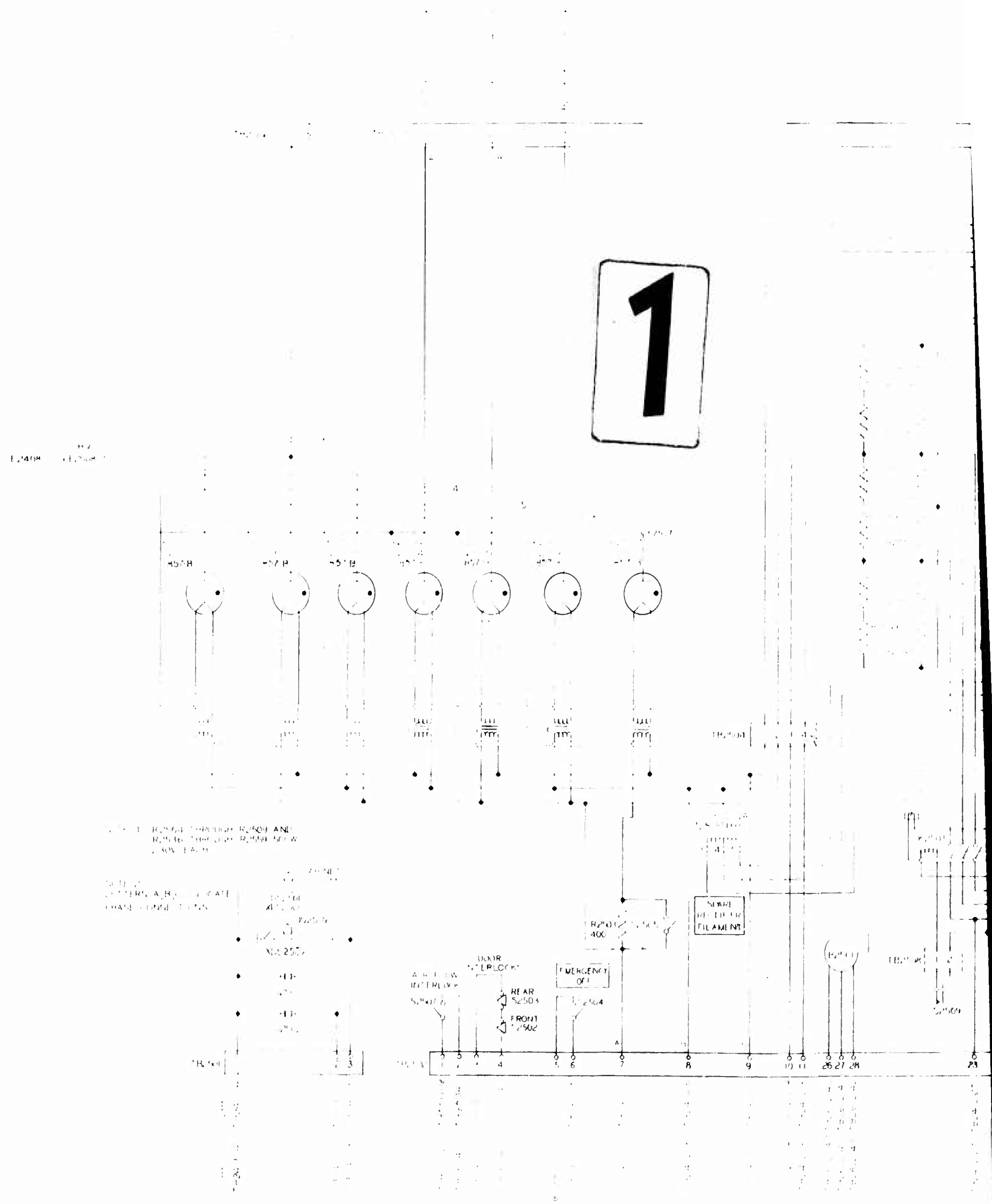


Figure 92. Rectifier Unit No. 1, Lower Portion of Rear Compartment.


1
DOOR
INTERLOCK
REAR
FRONT
EMERGENCY
OFF
SPARE
RECTIFIER
FILAMENT
400

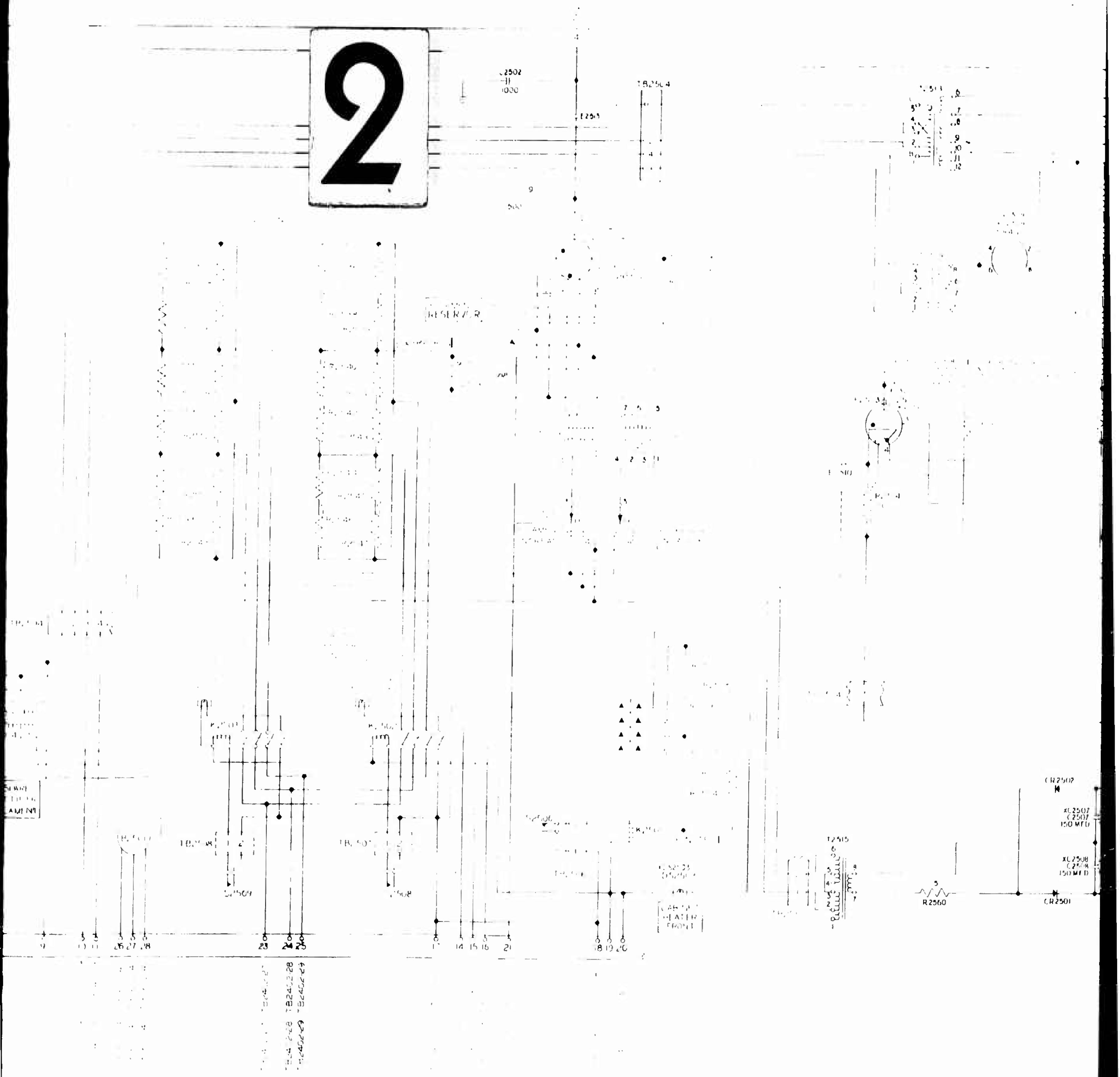


Figure 93. Schematic D

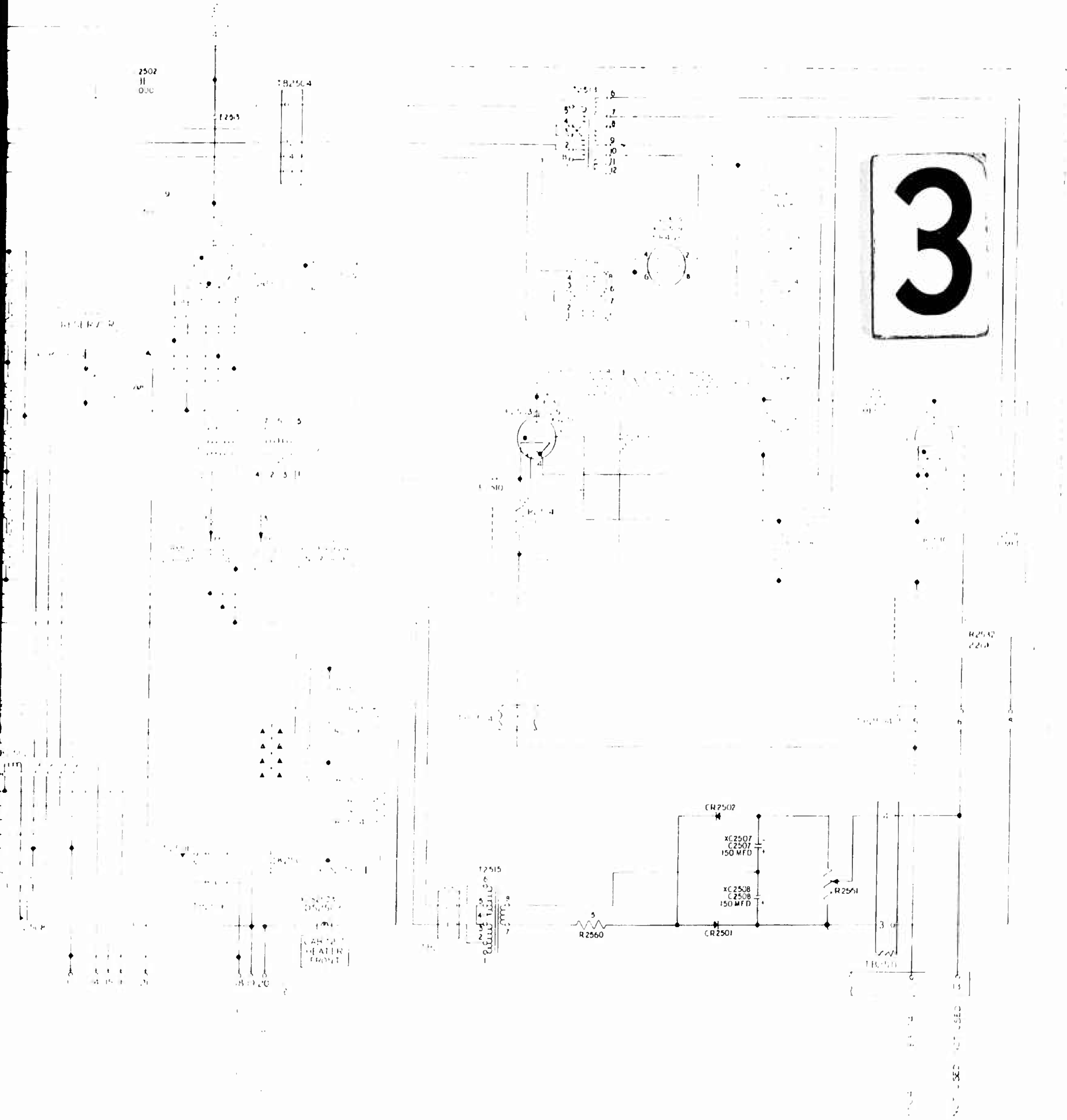


Figure 93. Schematic Diagram, Rectifier Unit No. 1.

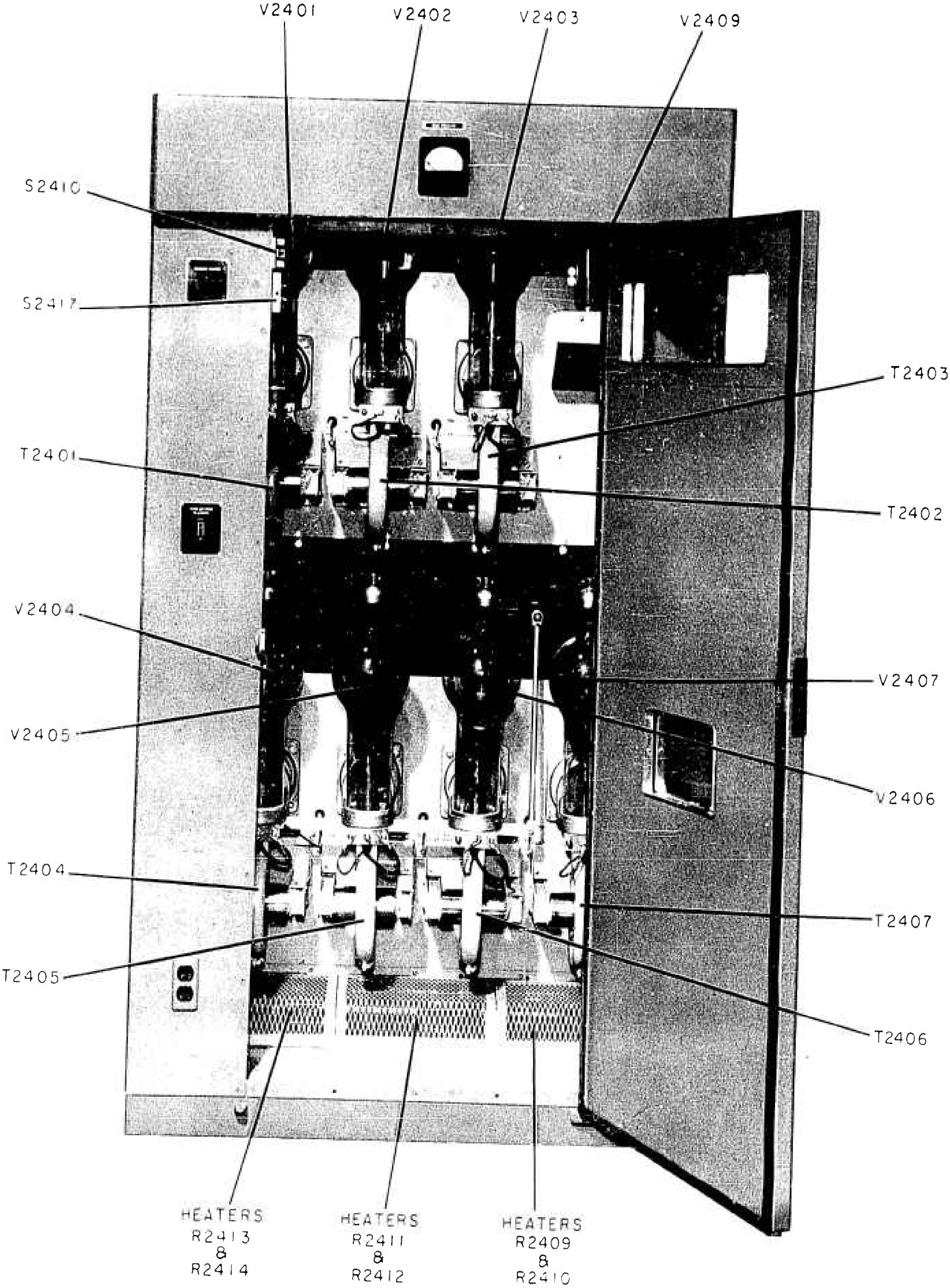


Figure 94. Rectifier Unit No. 2, Front View, Door Open.

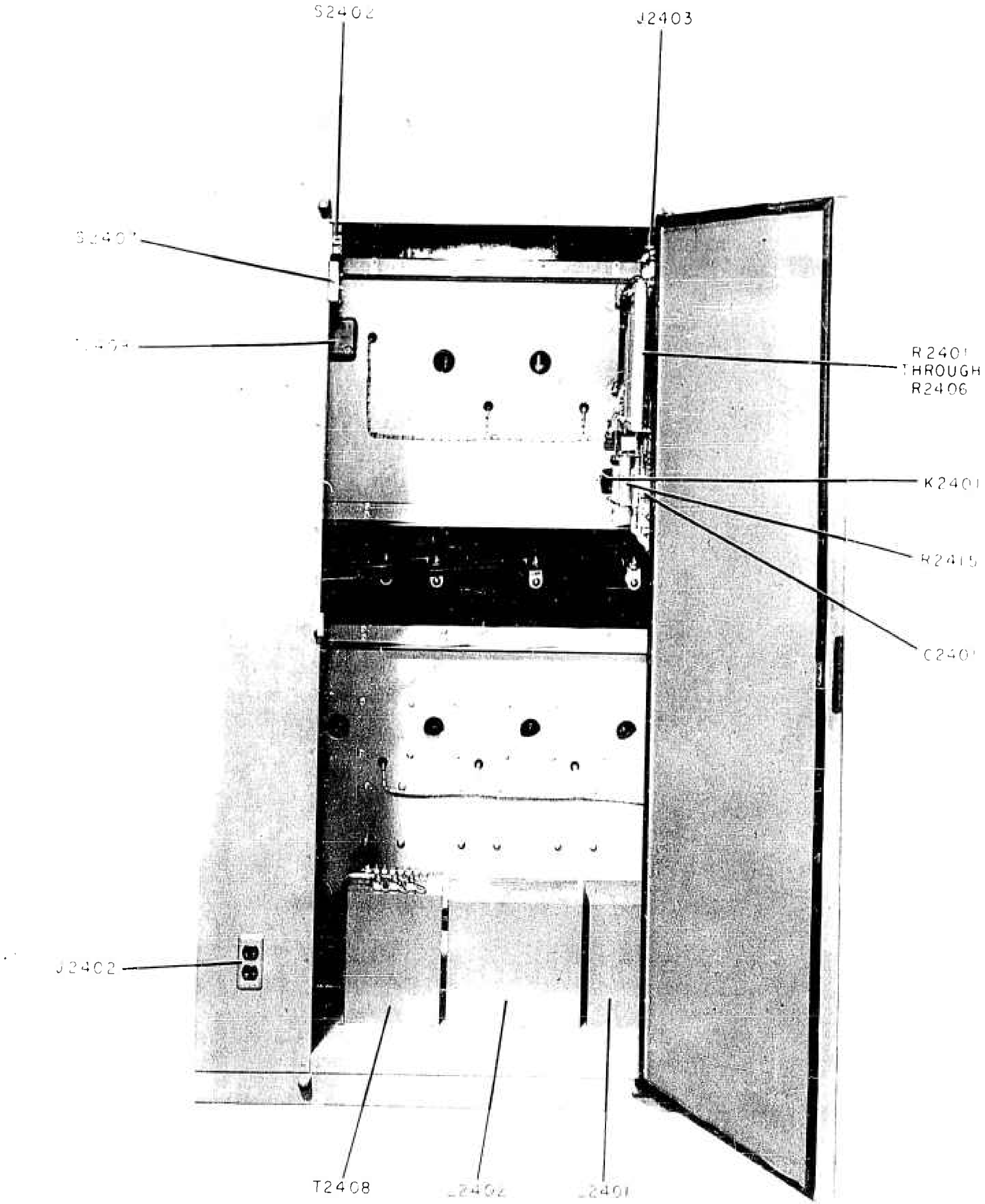
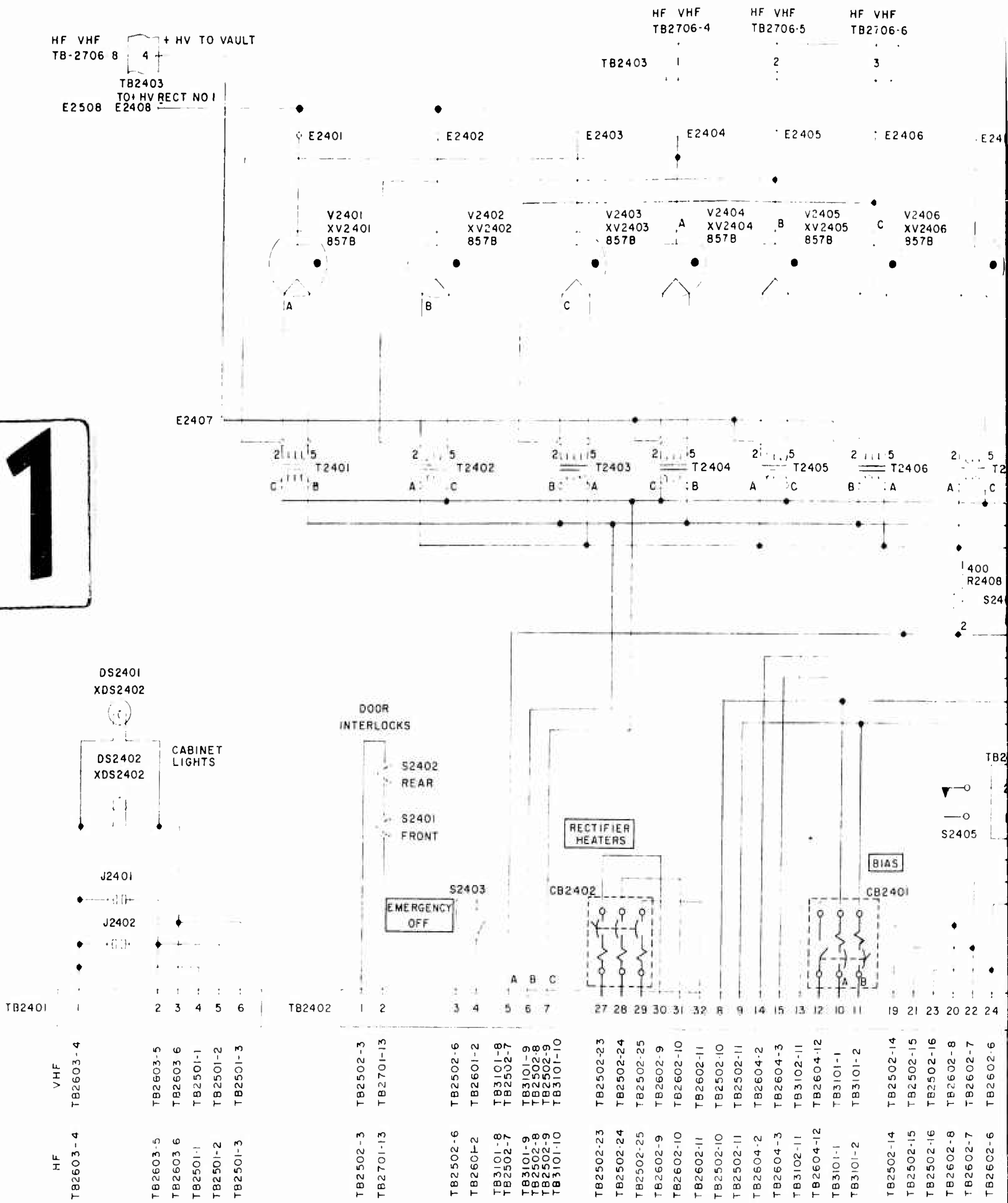


Figure 95. Rectifier Unit No. 2, Rear View, Door Open.



HF VHF
TB-2706 8
+ HV TO VAULT
TB2403
TO + HV RECT NO I
E2508 E2408
HF VHF
TB2706-4
HF VHF
TB2706-5
HF VHF
TB2706-6
TB2403
E2401
E2402
E2403
E2404
E2405
E2406
V2401
XV2401
857B
V2402
XV2402
857B
V2403
XV2403
857B
V2404
XV2404
857B
V2405
XV2405
857B
V2406
XV2406
857B
E2407
T2401
T2402
T2403
T2404
T2405
T2406
400
R2408
DS2401
XDS2402
DS2402
XDS2402
CABINET
LIGHTS
DOOR
INTERLOCKS
S2402
REAR
S2401
FRONT
RECTIFIER
HEATERS
S2403
EMERGENCY
OFF
CB2402
BIAS
CB2401
S2405
J2401
J2402
TB2401
TB2402
VHF
HF
TB2603-4
TB2603-5
TB2603 6
TB2501-1
TB2501-2
TB2501-3
TB2502-3
TB2701-13
TB2502-6
TB2601-2
TB3101-8
TB2502-7
TB3101-9
TB2502-8
TB2502-9
TB3101-10
TB2502-23
TB2502-24
TB2502-25
TB2602-9
TB2602-10
TB2602-11
TB2502-10
TB2502-11
TB2604-2
TB2604-3
TB3102-11
TB2604-12
TB3101-1
TB3101-2
TB2502-14
TB2502-15
TB2502-16
TB2602-8
TB2602-7
TB2602-6

1

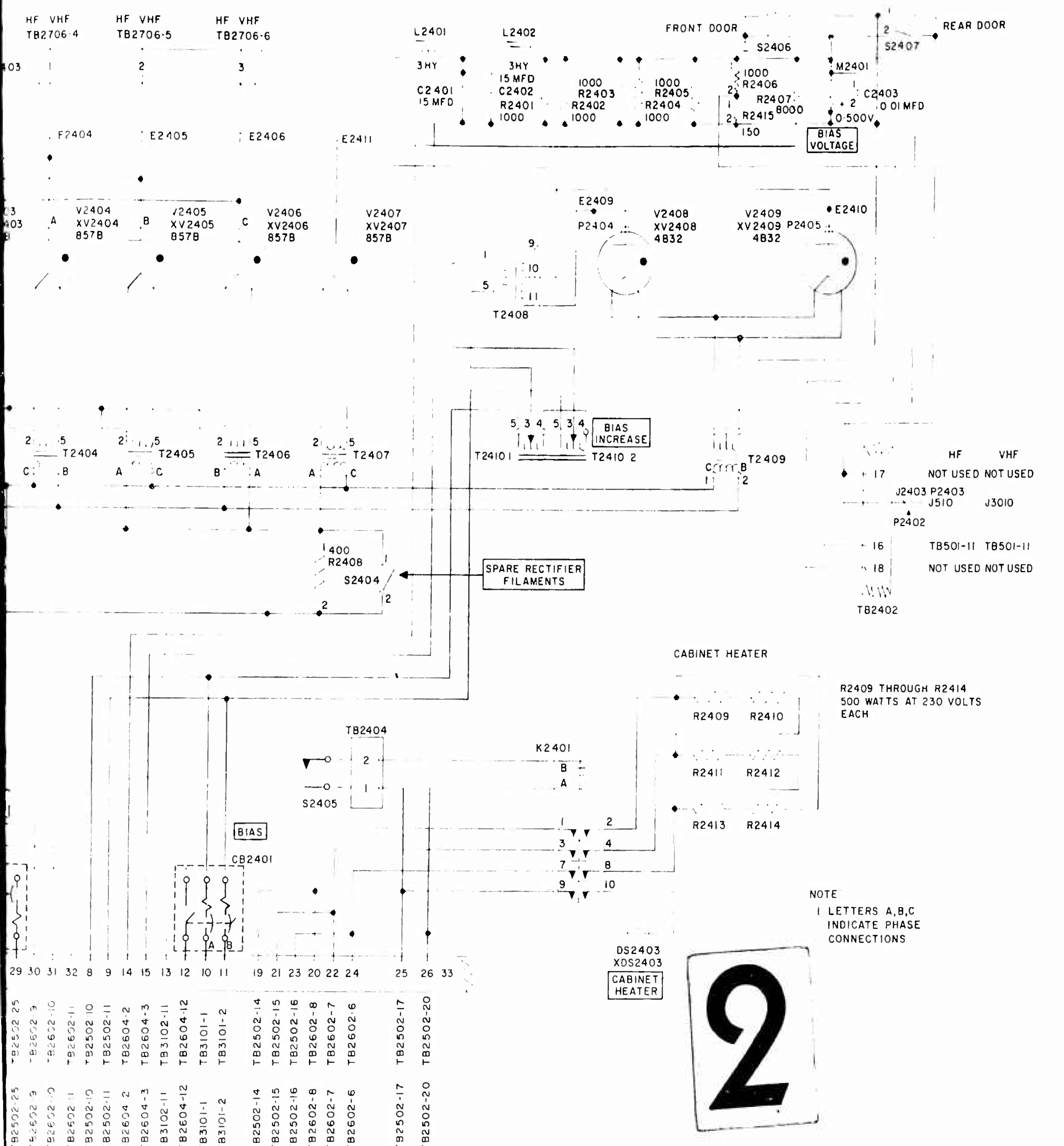


Figure 96.

Schematic Diagram, Rectifier Unit No. 2.

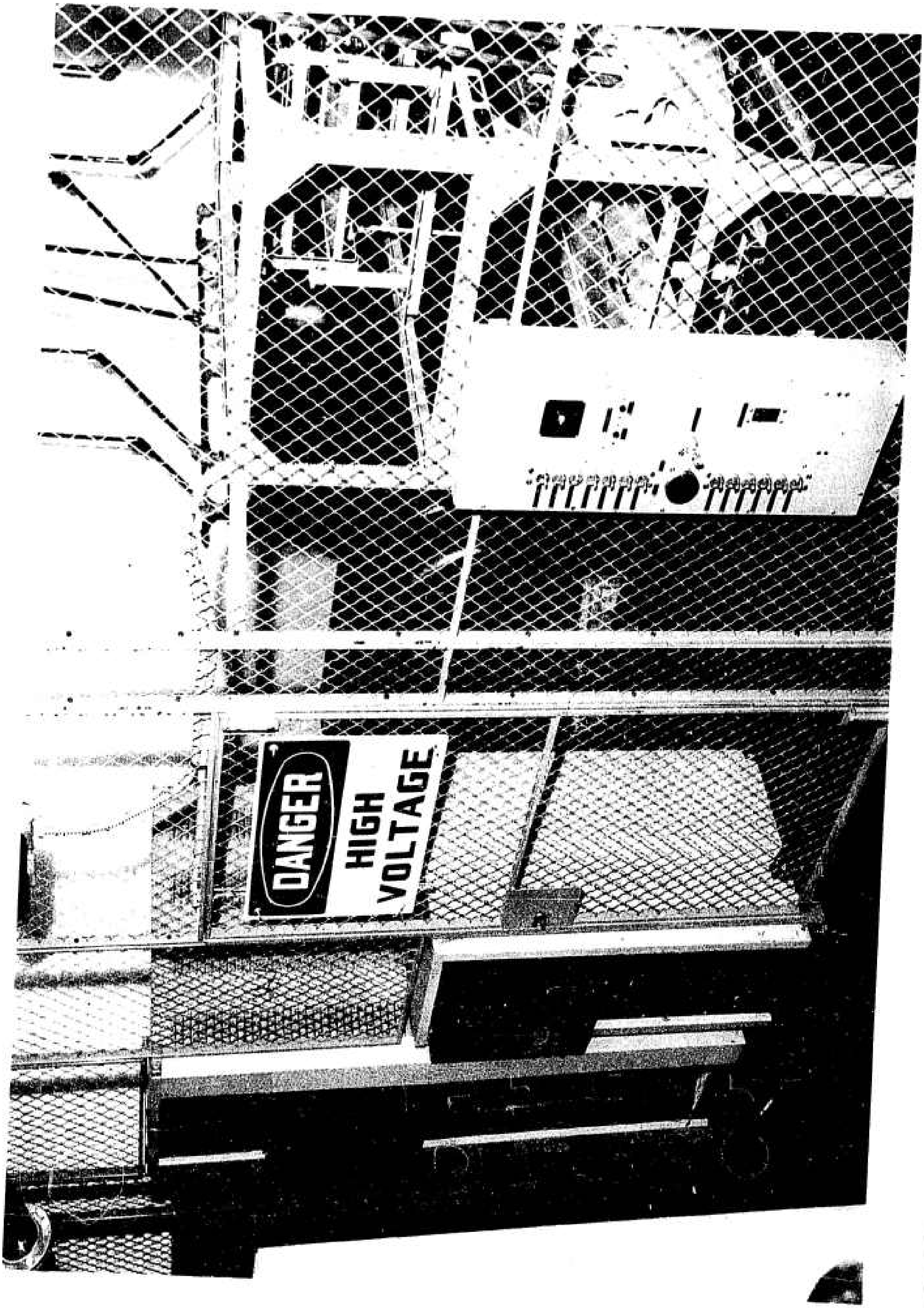


Figure 97. Power Vault Showing Regulators and Key Transfer Box.

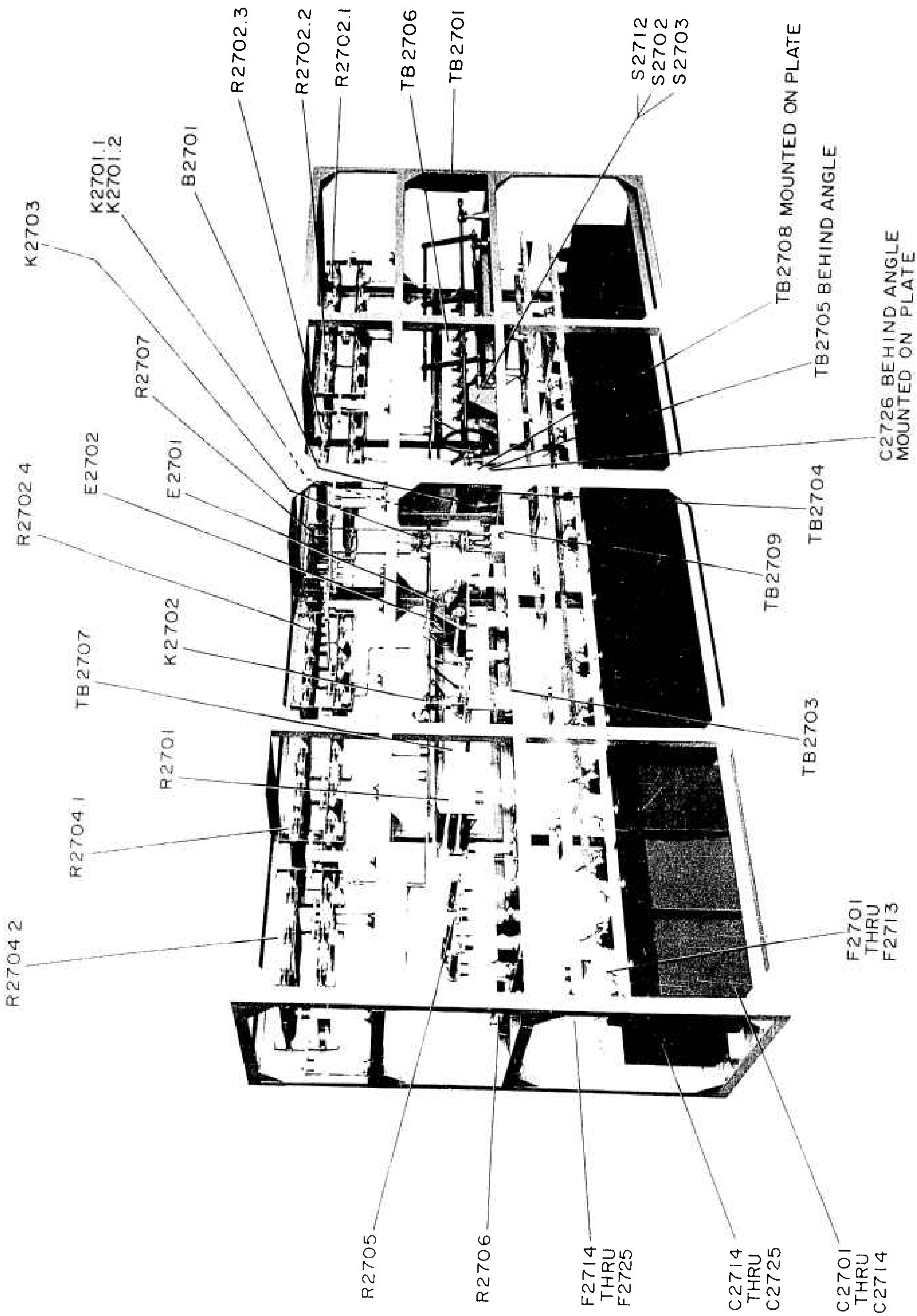


Figure 98. Filter Rack, Oblique View.

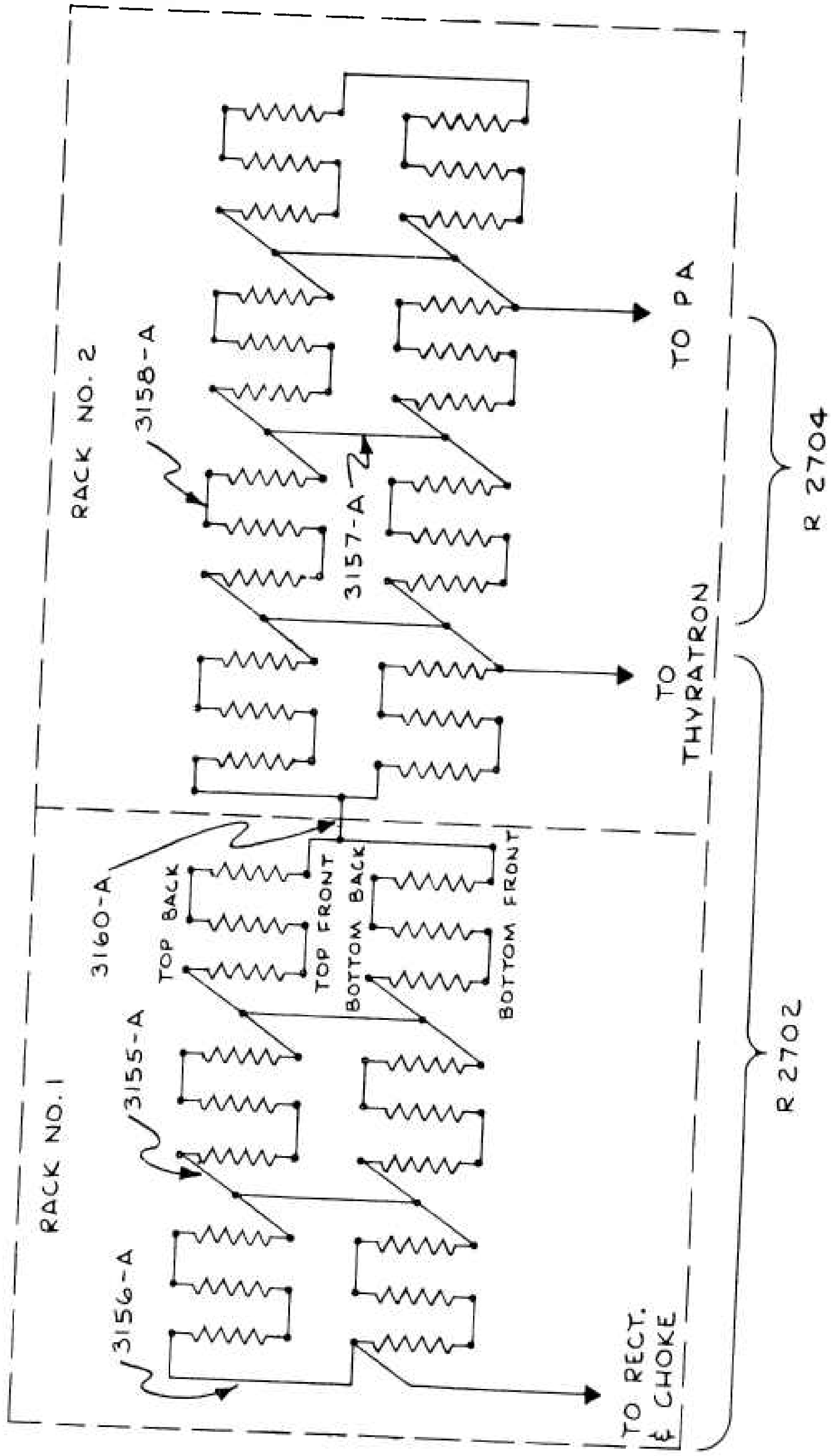
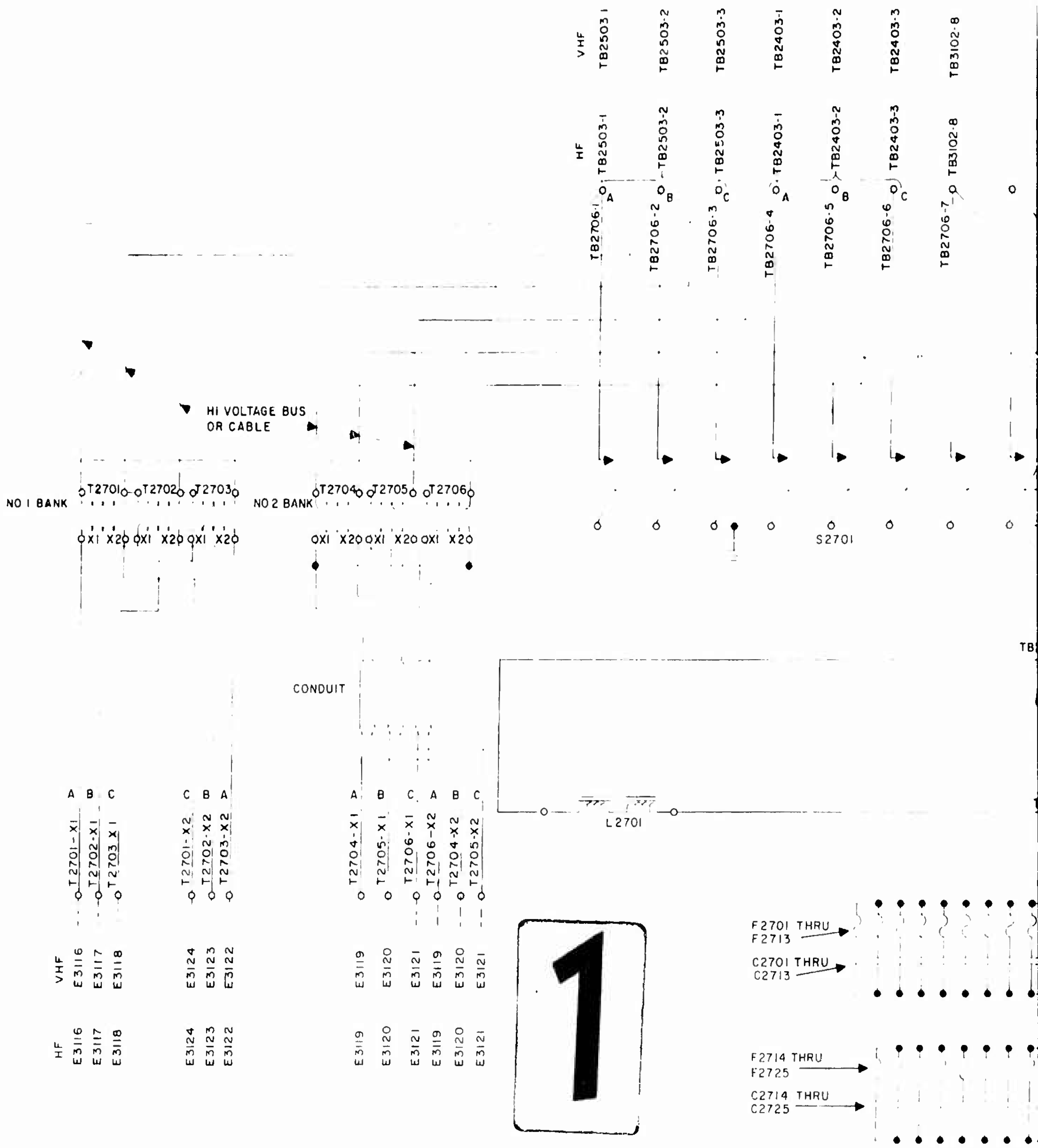


Figure 99. Schematic Diagram, Resistors R2701, R2702, R2704 and R2707.



NOTE 1 K2701 1 & K2701 2 ARE MECHANICALLY
INTERLOCKED BOTH CANNOT BE ACTUATED
AT ONCE

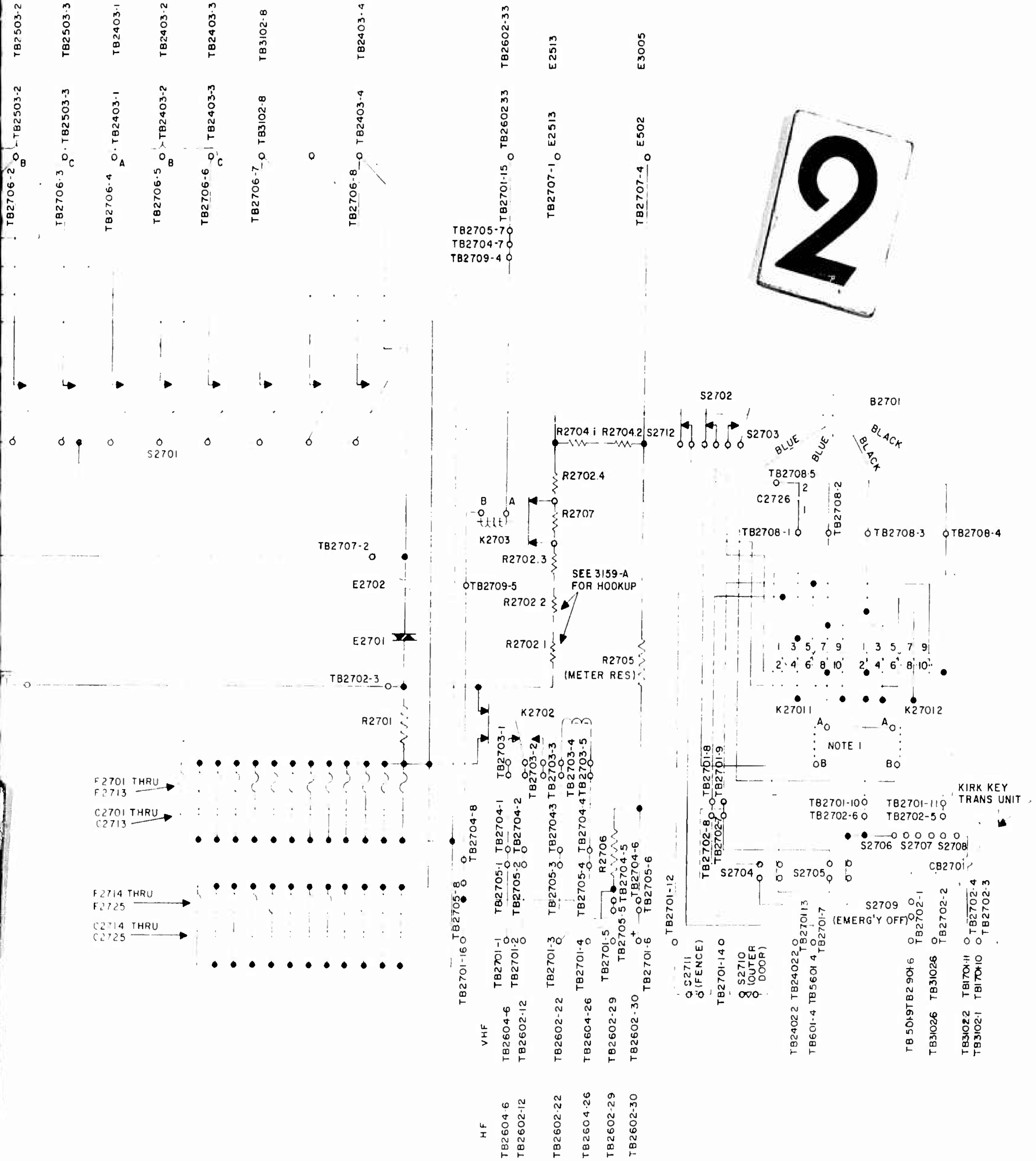


Figure 100. Schematic Diagram, External Power Equipment.

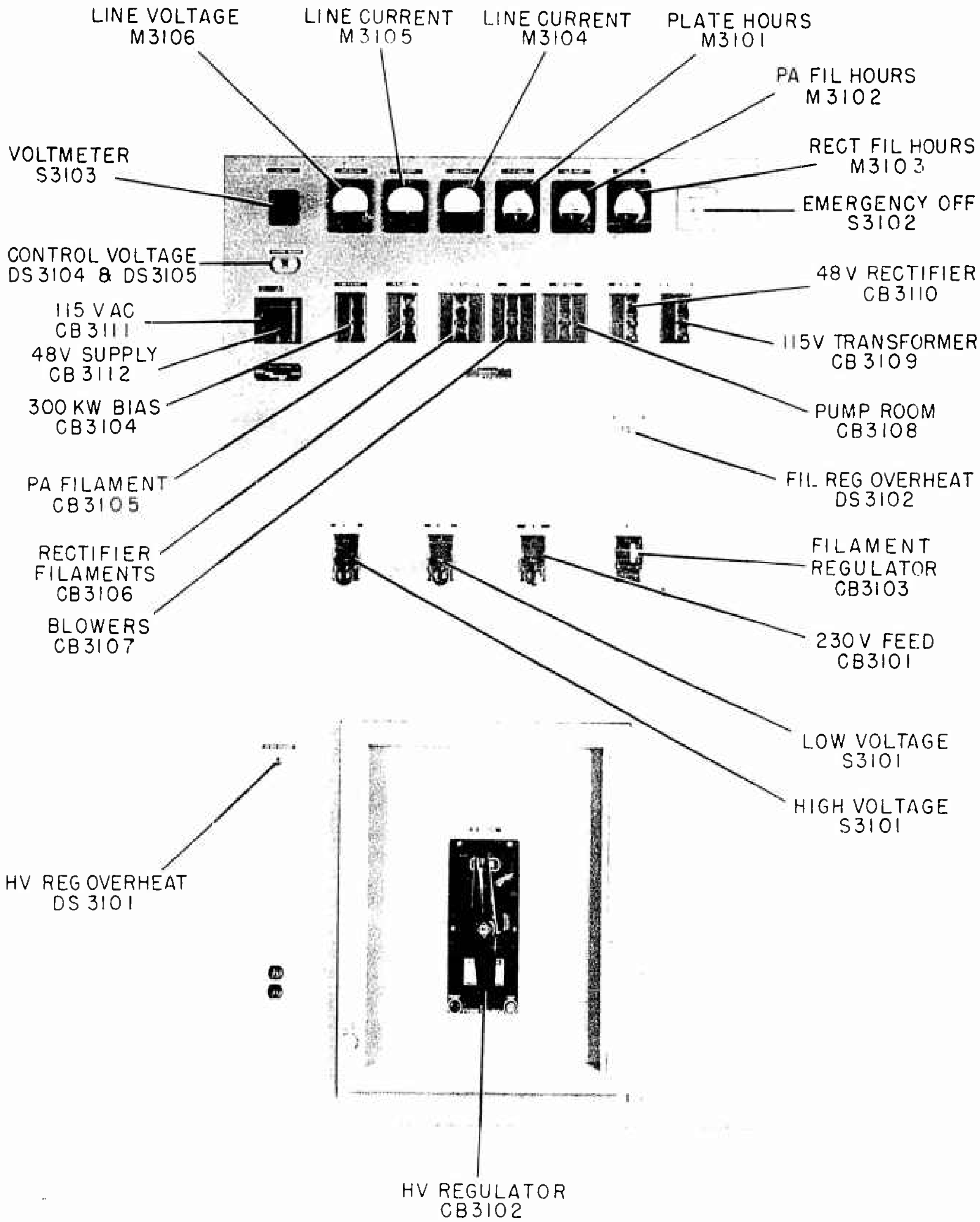


Figure 101. Distribution Unit, Location of Controls and Instruments.

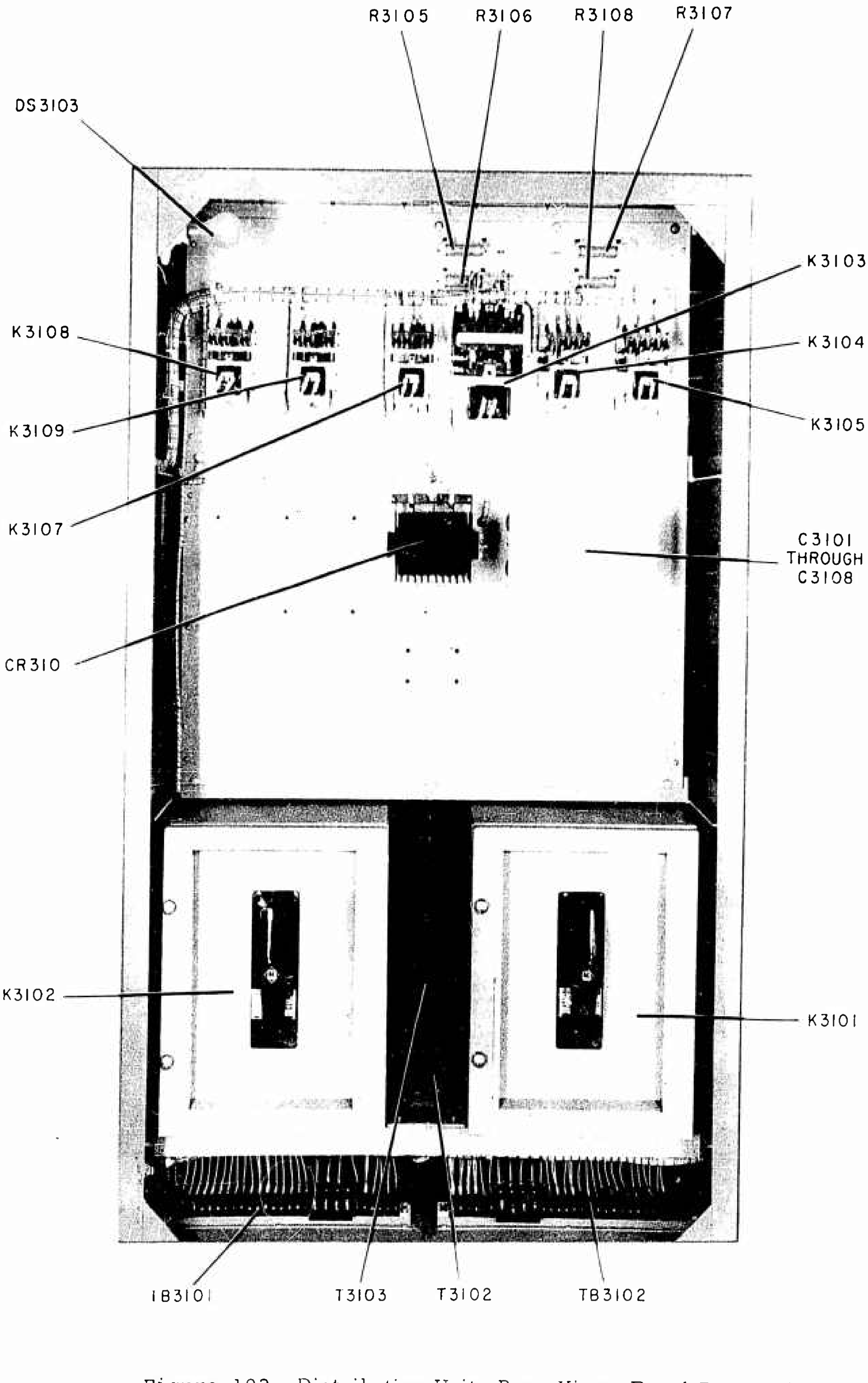


Figure 102. Distribution Unit, Rear View, Panel Removed.

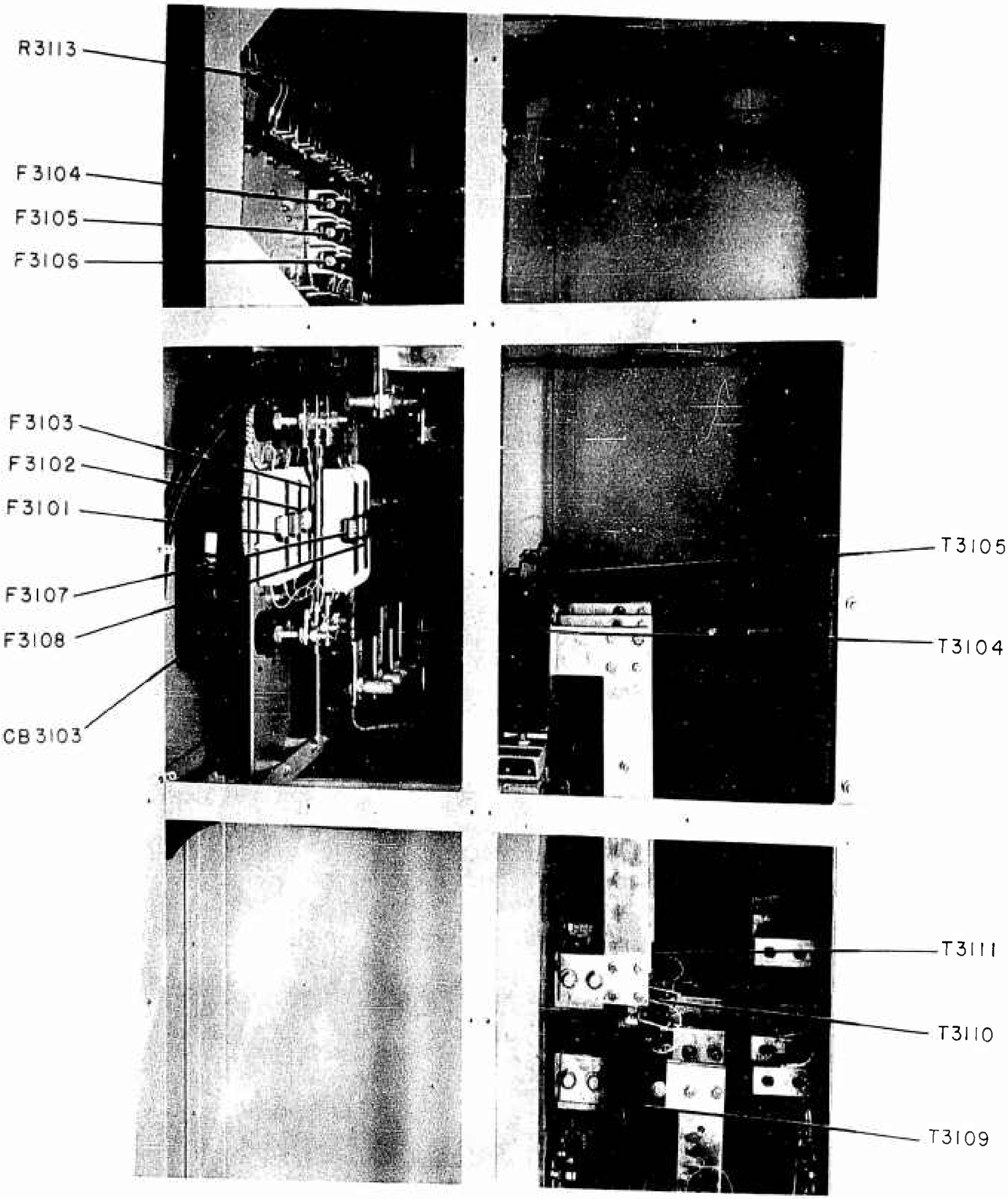


Figure 103. Distribution Unit, Front Portion of Interior.

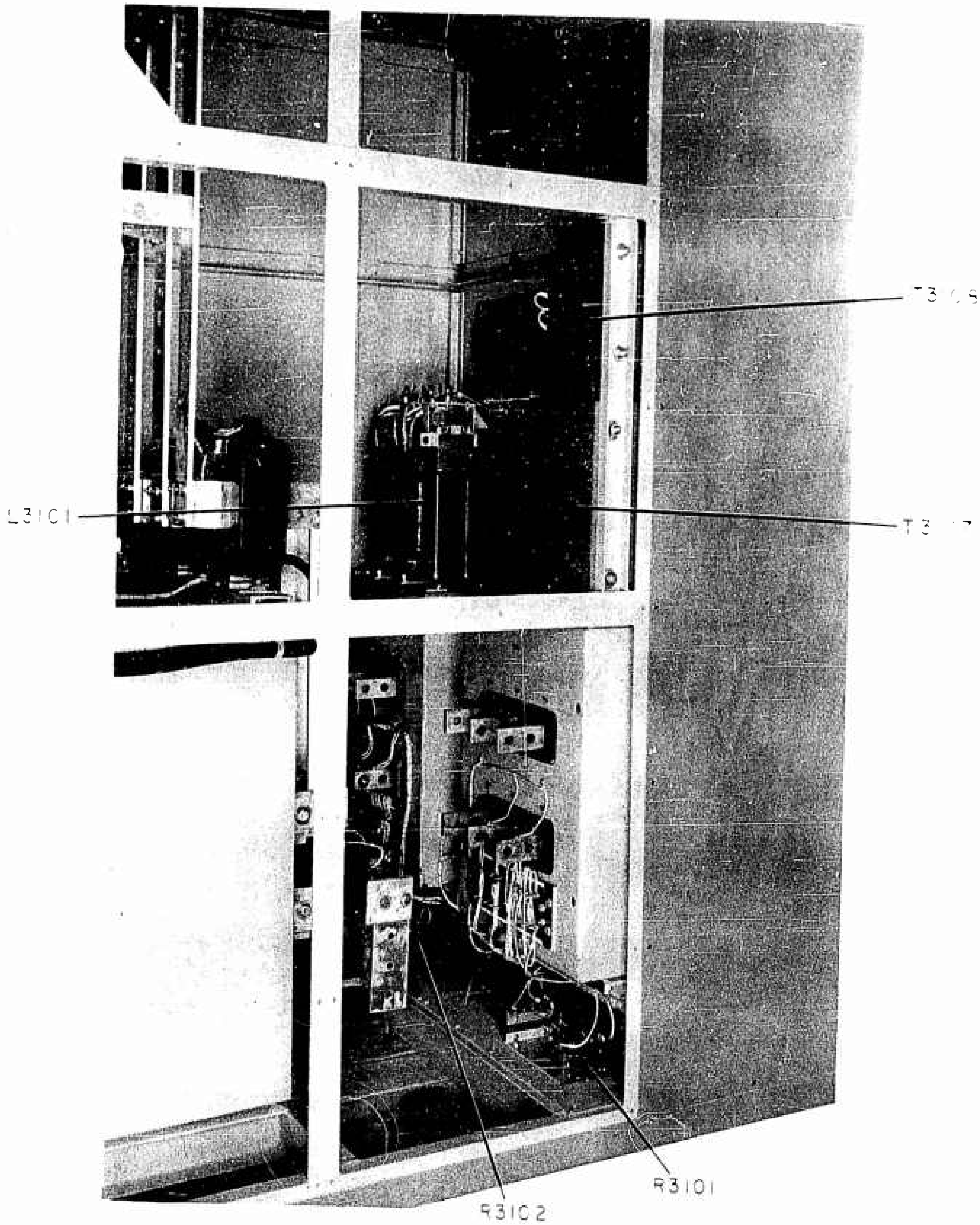


Figure 104. Distribution Unit, Rear Portion of Interior.

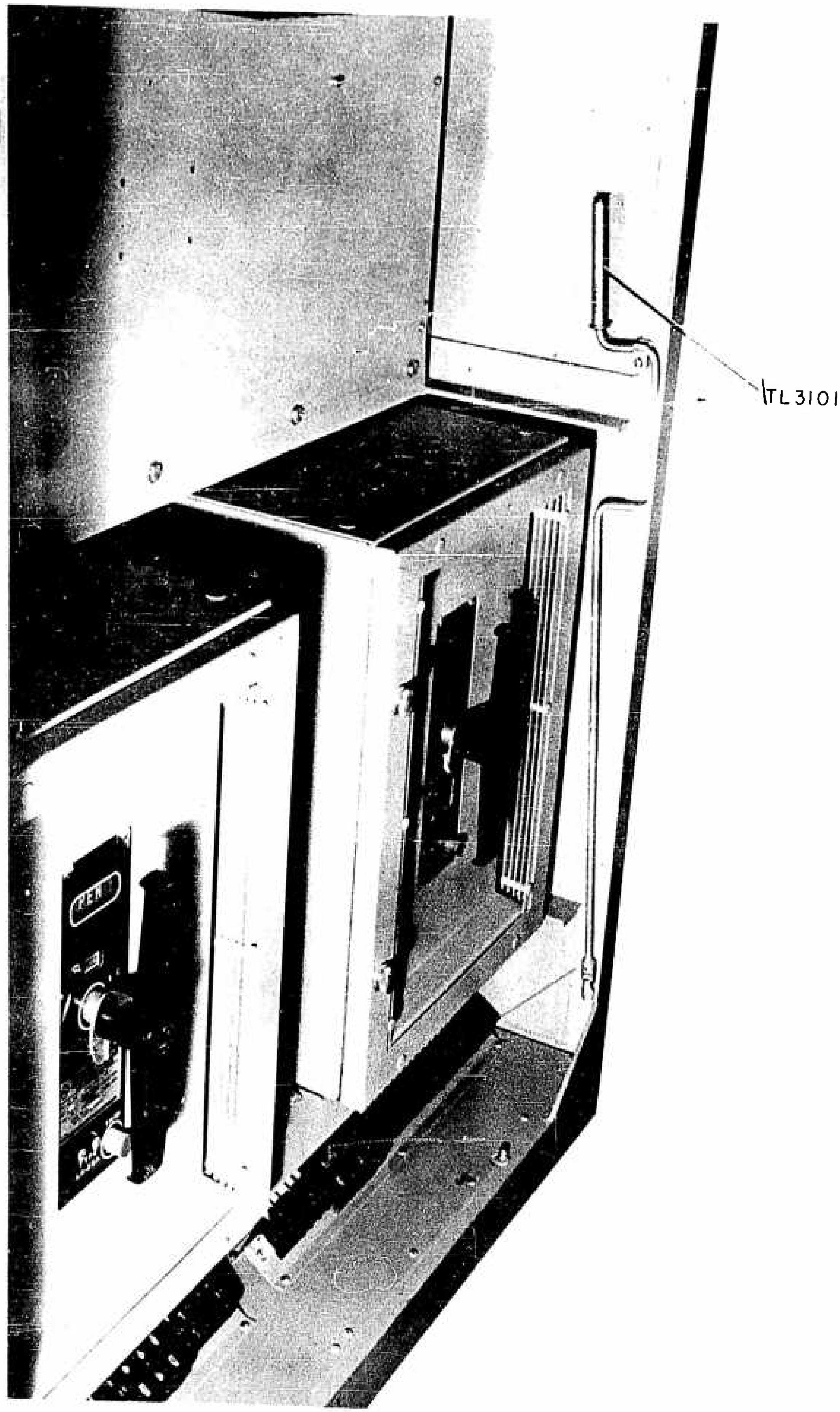


Figure 105. Circuit Breaker Drawout Wrench TL3101.

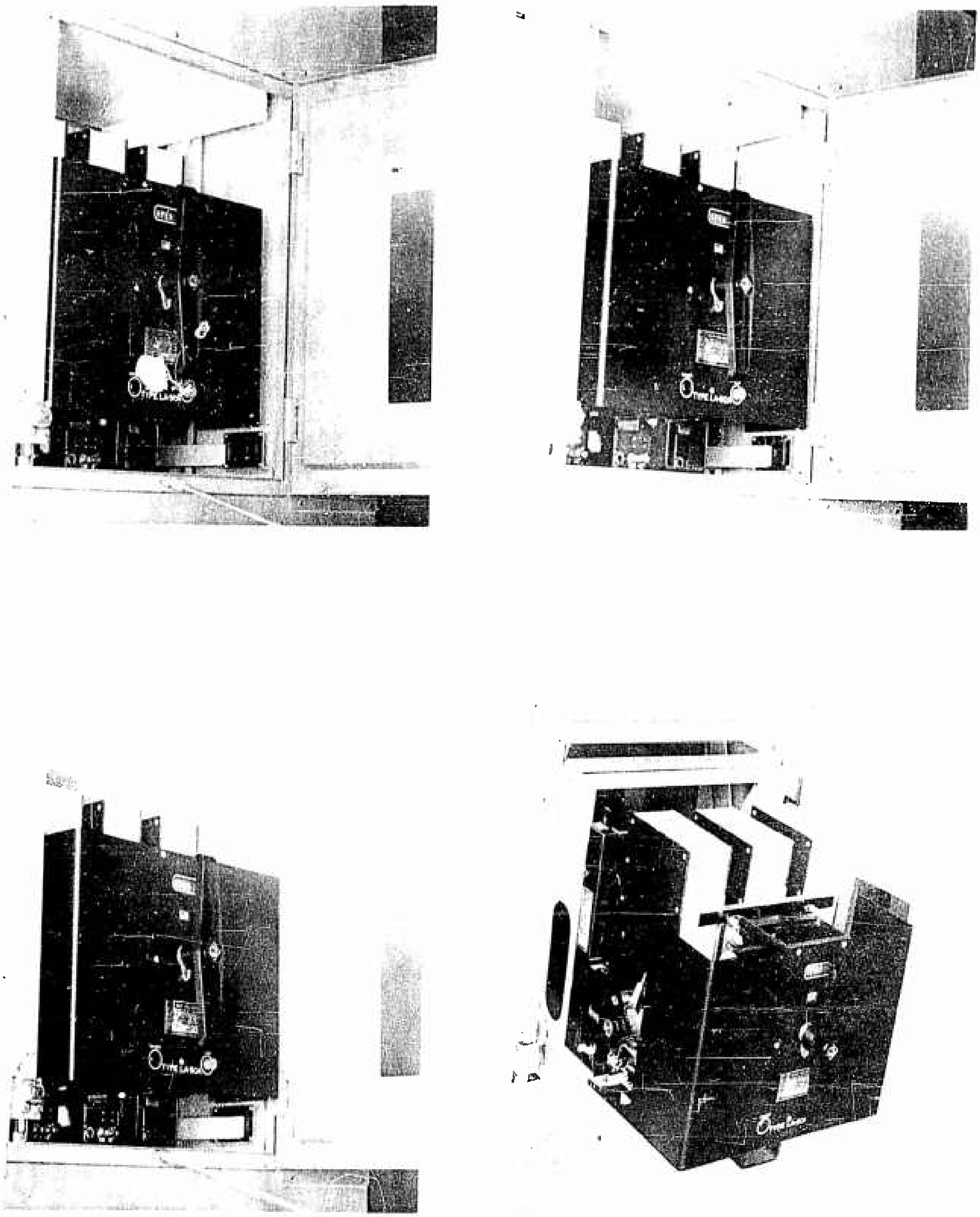
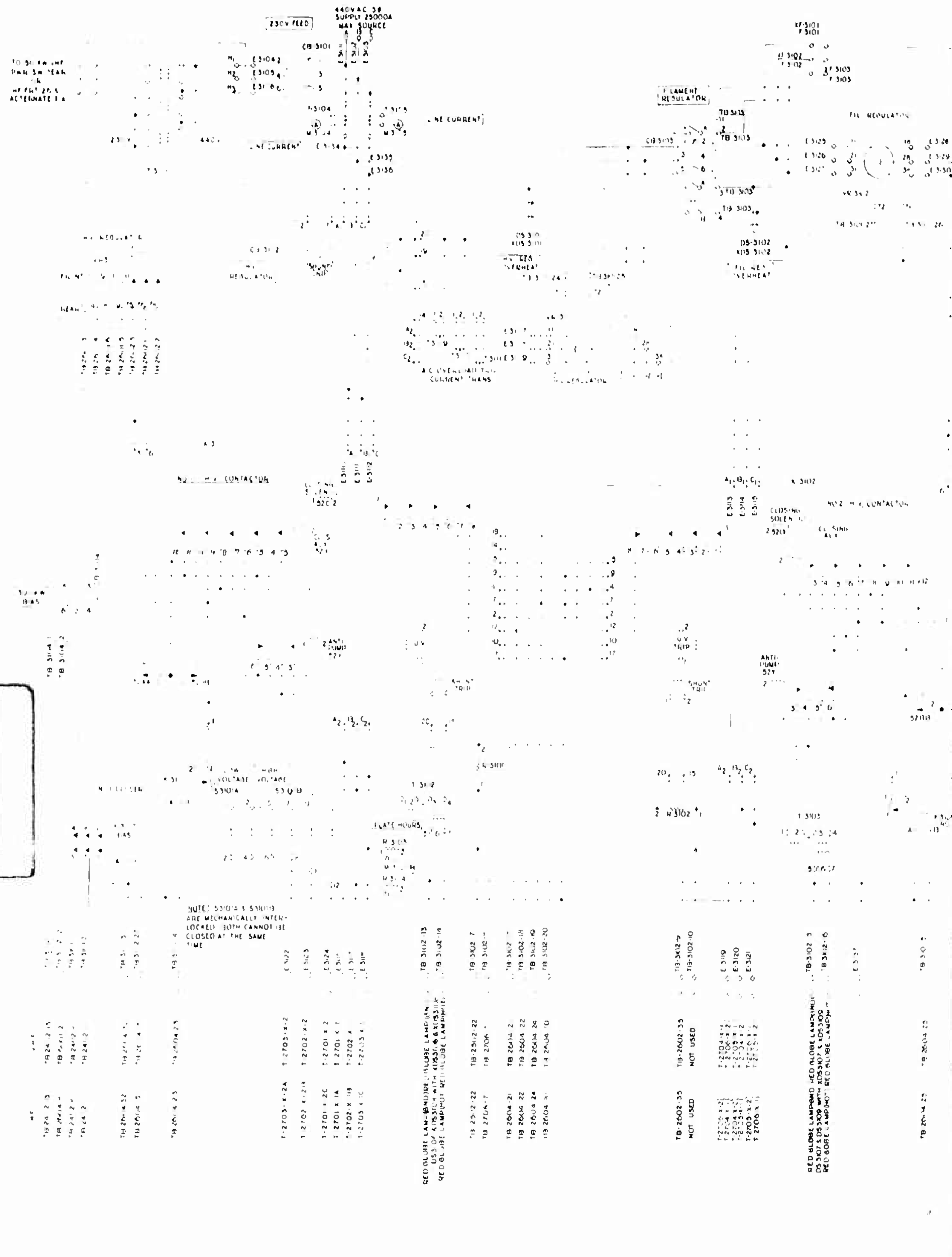


Figure 106. Drawing Out HV REGULATOR Circuit Breaker CB3102.


230V FEED
440VAC 3Ø
SUPPLY 25000A
MAX SOURCE
CB 3101
LINE CURRENT
FILAMENT
REGULATOR
TB 3103
FIL REGULATOR
DS-3102
XDS 3102
FIL RES
OVERHEAT
H.V. CONTACTOR
CLOSING
SOLENOID
ANTI-
PUMP
52Y
PLATE HOURS
NOTE: S3101A & S3101B
ARE MECHANICALLY INTER-
LOCKED. BOTH CANNOT BE
CLOSED AT THE SAME
TIME
NOT USED

1

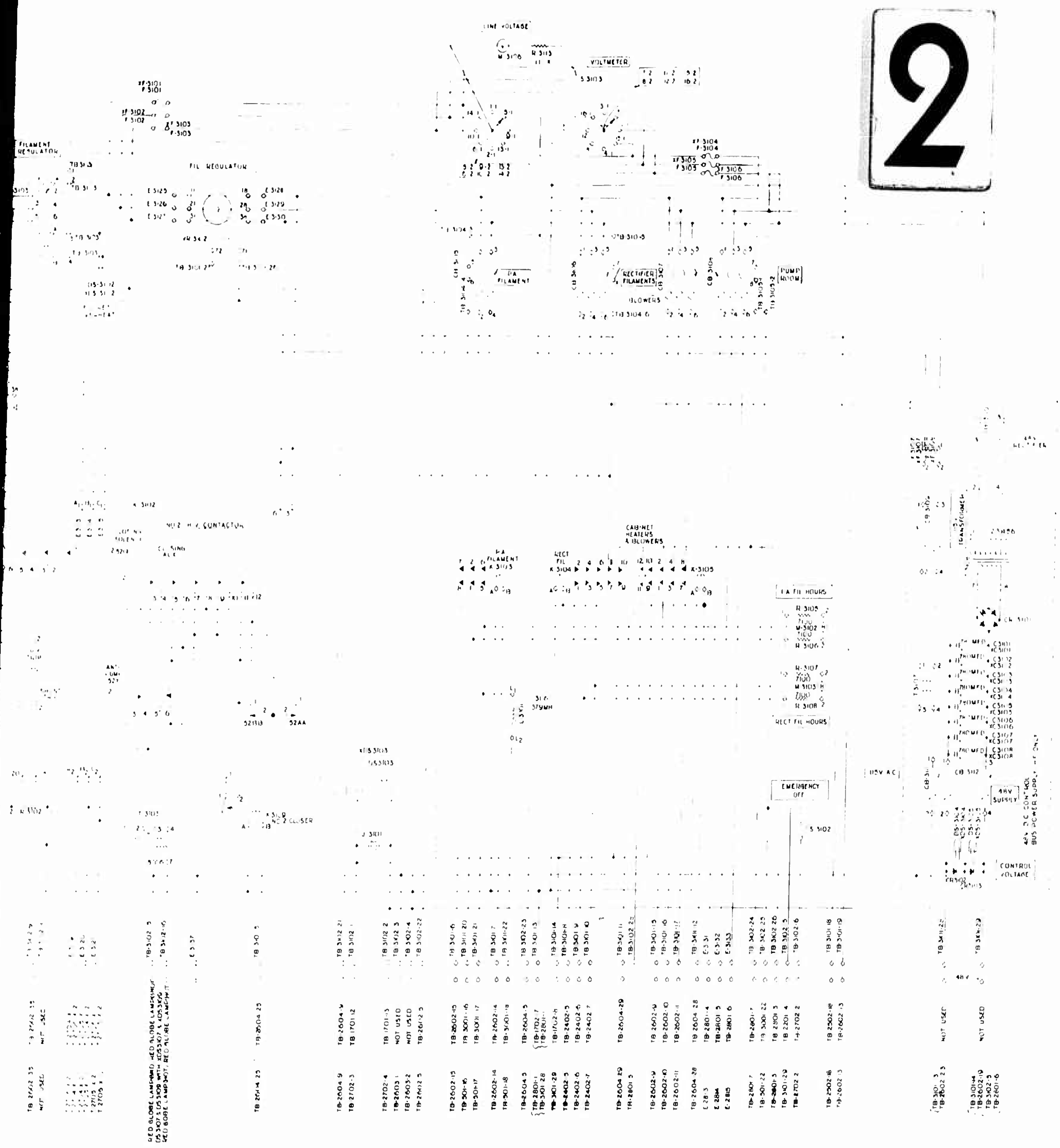
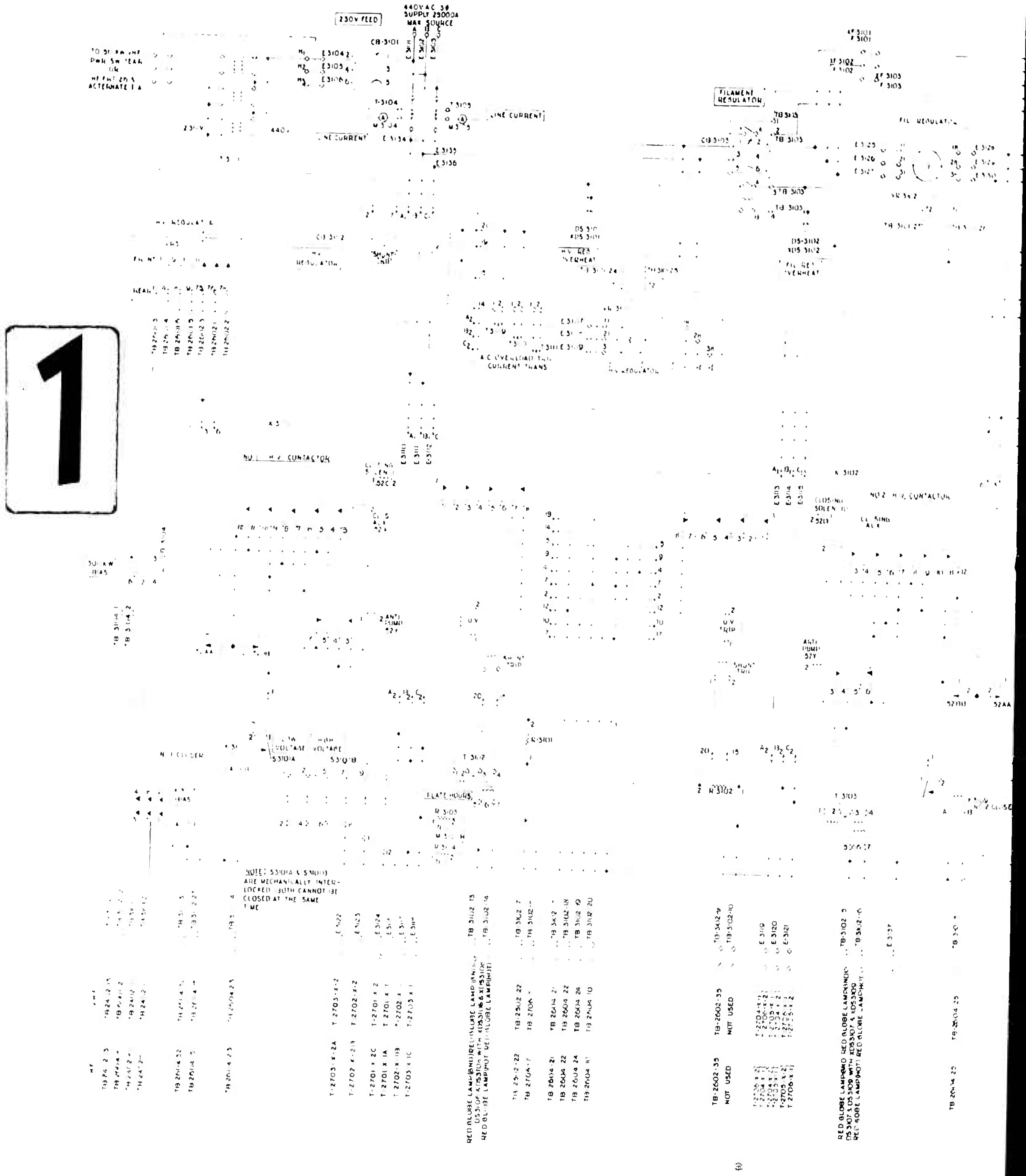


Figure 107.
Schematic Diagram, Distribution Unit.


230V FEED
440VAC 3Ø SUPPLY 25000A MAX SOURCE
CB-3101
LINE CURRENT
FILAMENT REGULATOR
FIL REGULATOR
NO.1 H.V. CONTACTOR
NO.2 H.V. CONTACTOR
A.C. OVERLOAD TRIP CURRENT TRANS
PLATE HOURS
NOTE: S3101A & S3101B ARE MECHANICALLY INTERLOCKED. BOTH CANNOT BE CLOSED AT THE SAME TIME
RED GLOBE LAMP(AND)RED GLOBE LAMP(AND) DS3107 & DS3109 WITH XDS3107 & XDS3109 RED GLOBE LAMP(HOT) RED GLOBE LAMP(HOT)
TB-2602-35 NOT USED

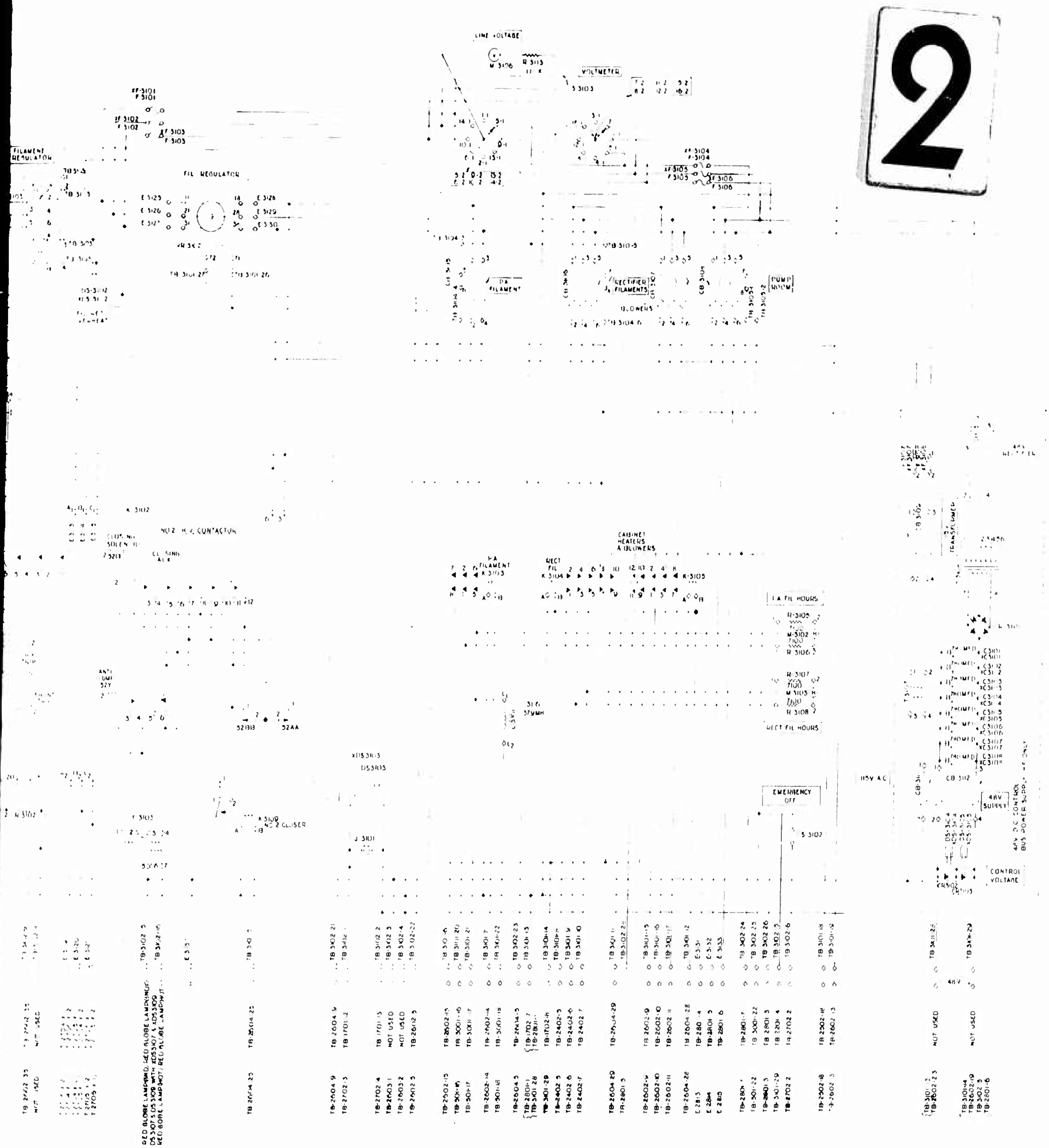
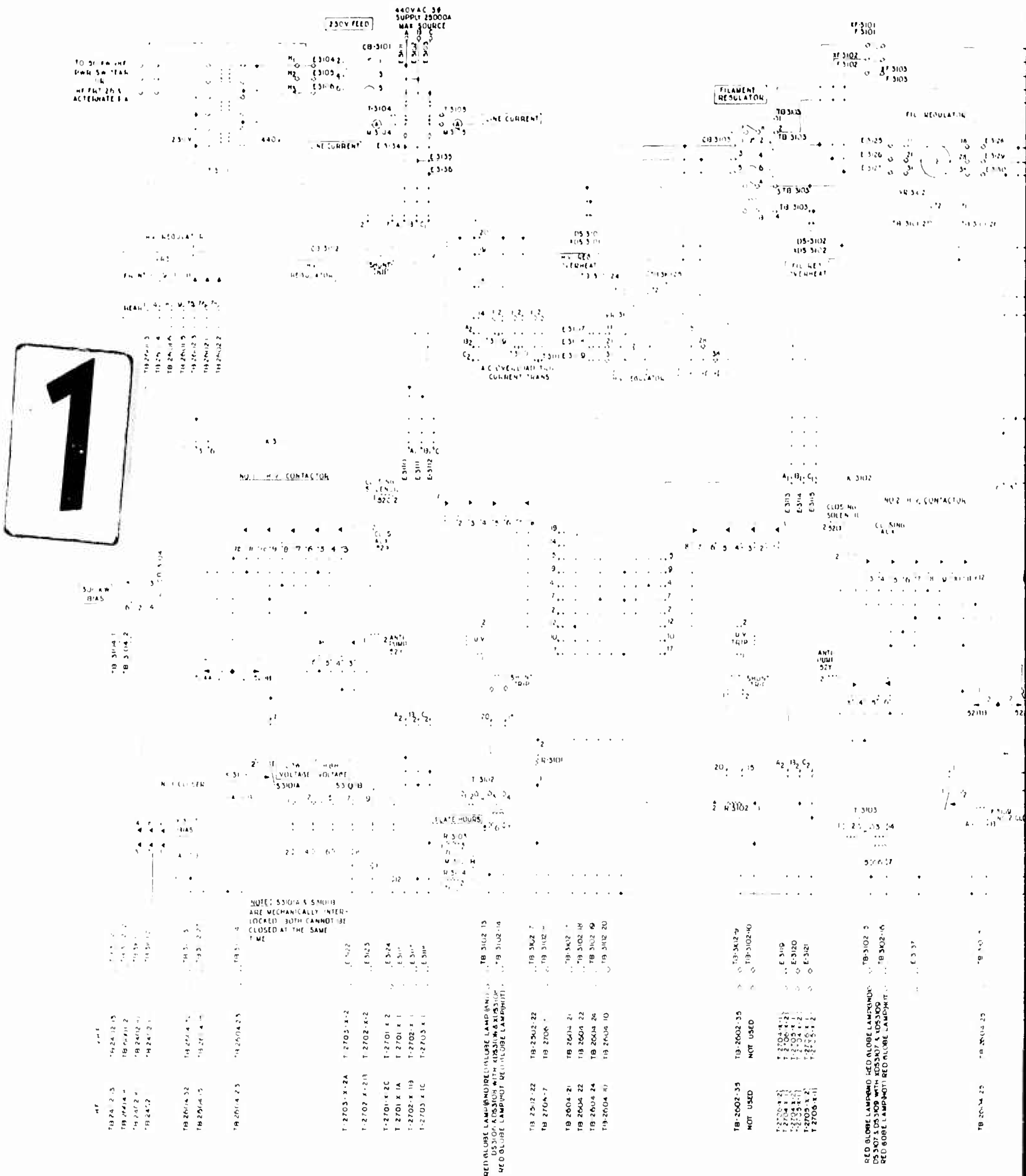


Figure 107.

Schematic Diagram, Distribution Unit.



440VAC 3Ø SUPPLY 25000A MAX SOURCE
230V FEED
CB-3101
FILAMENT REGULATOR
LINE CURRENT
NO.1 H.V. CONTACTOR
NO.2 H.V. CONTACTOR
A.C. OVERLOAD TRIP CURRENT TRANS
PLATE HOURS
NOTE: S3101A & S3101B ARE MECHANICALLY INTERLOCKED. BOTH CANNOT BE CLOSED AT THE SAME TIME

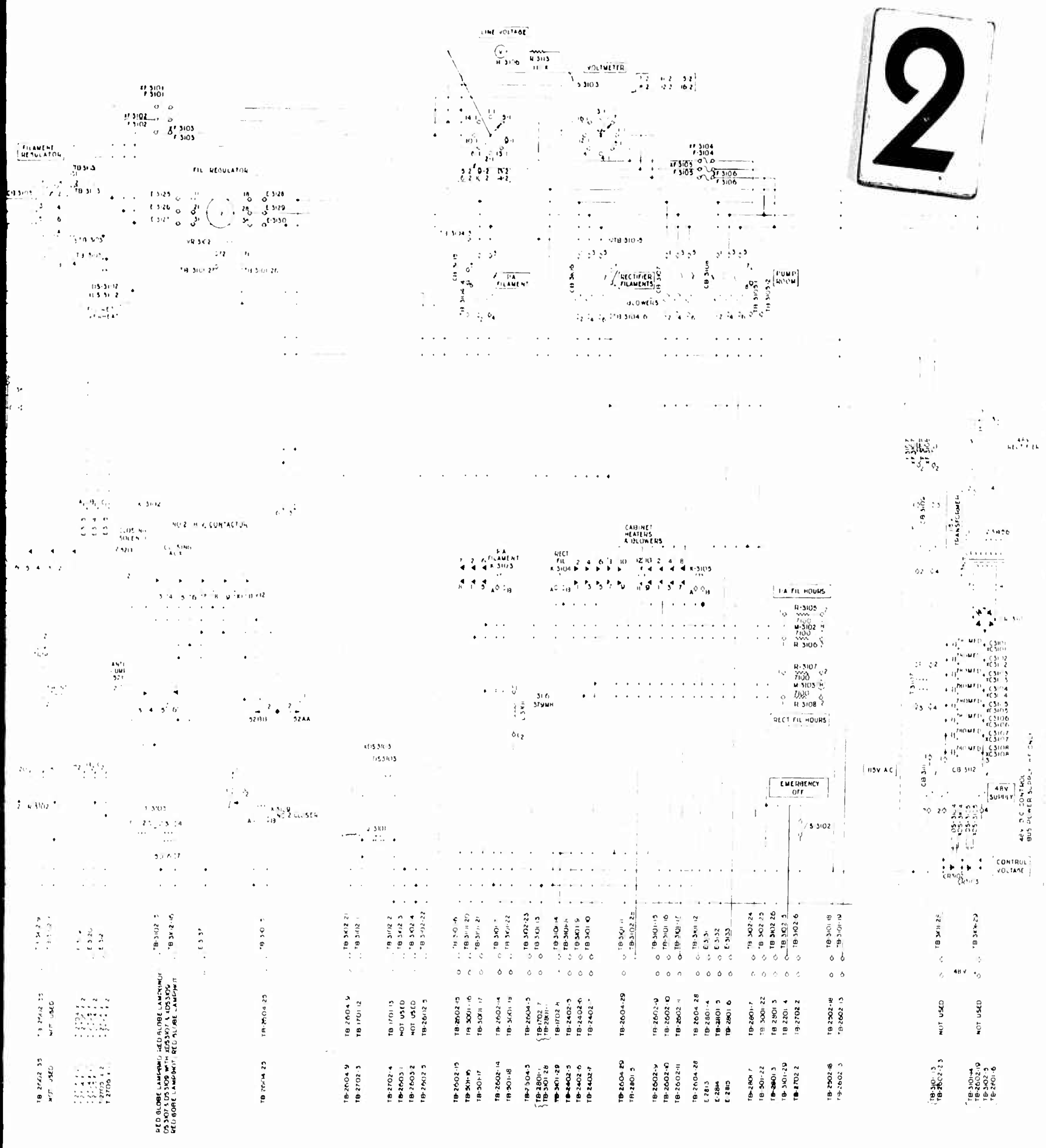


Figure 107.

Schematic Diagram, Distribution Unit.

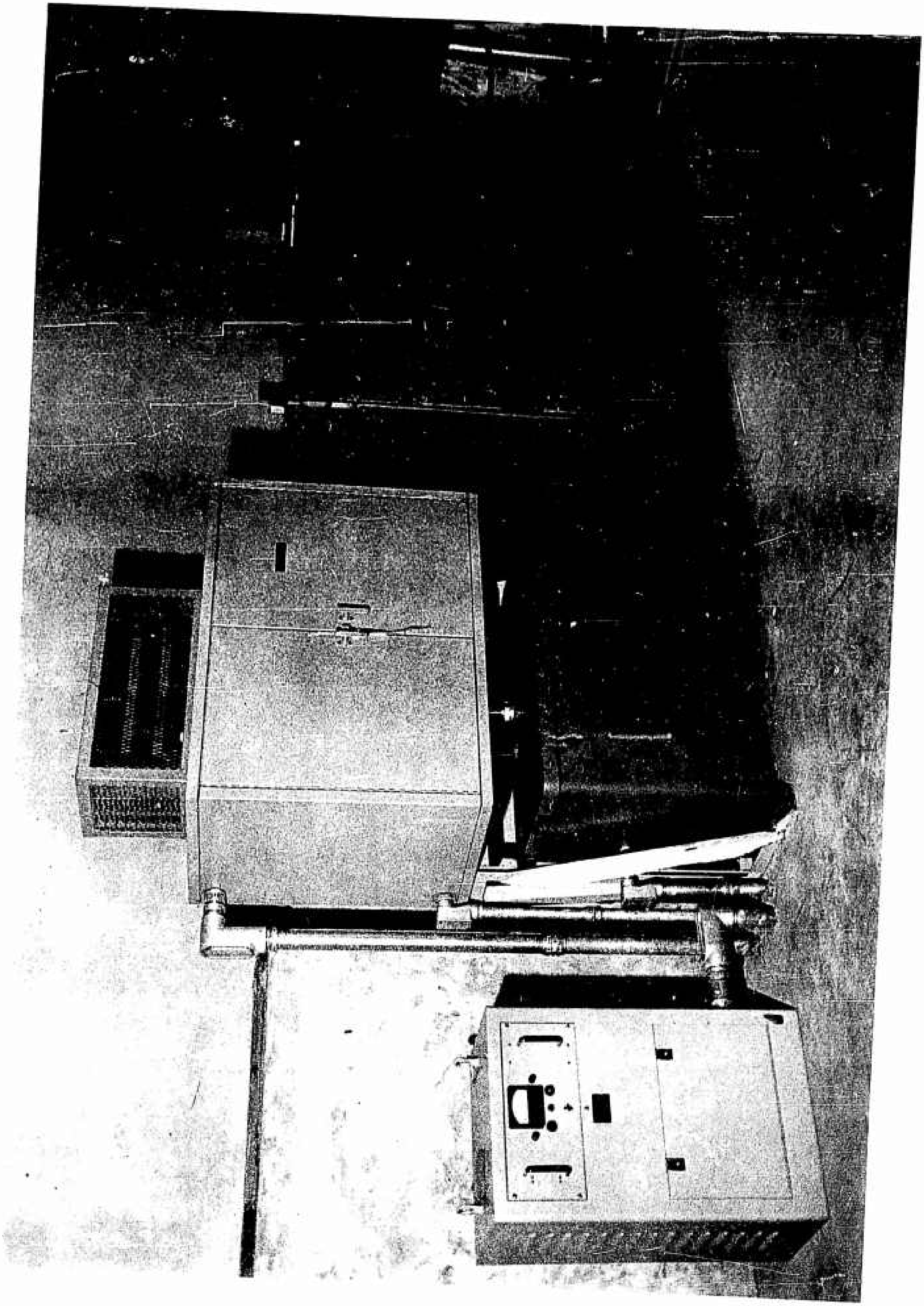


Figure 108. 40-Kw Amplifier Group External Power Equipment.

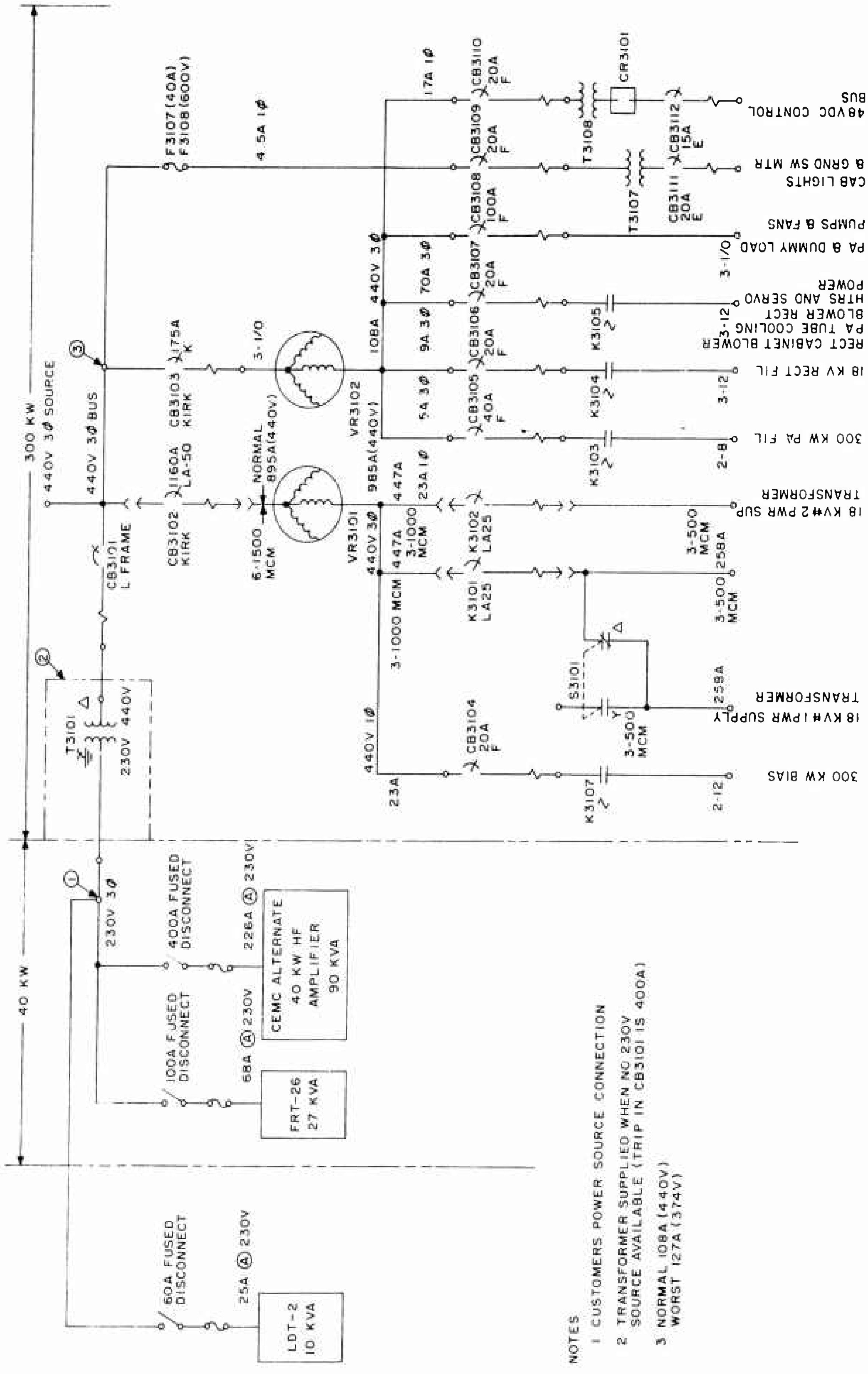


Figure 109. One-Line Schematic Diagram, Power Distribution Circuit.

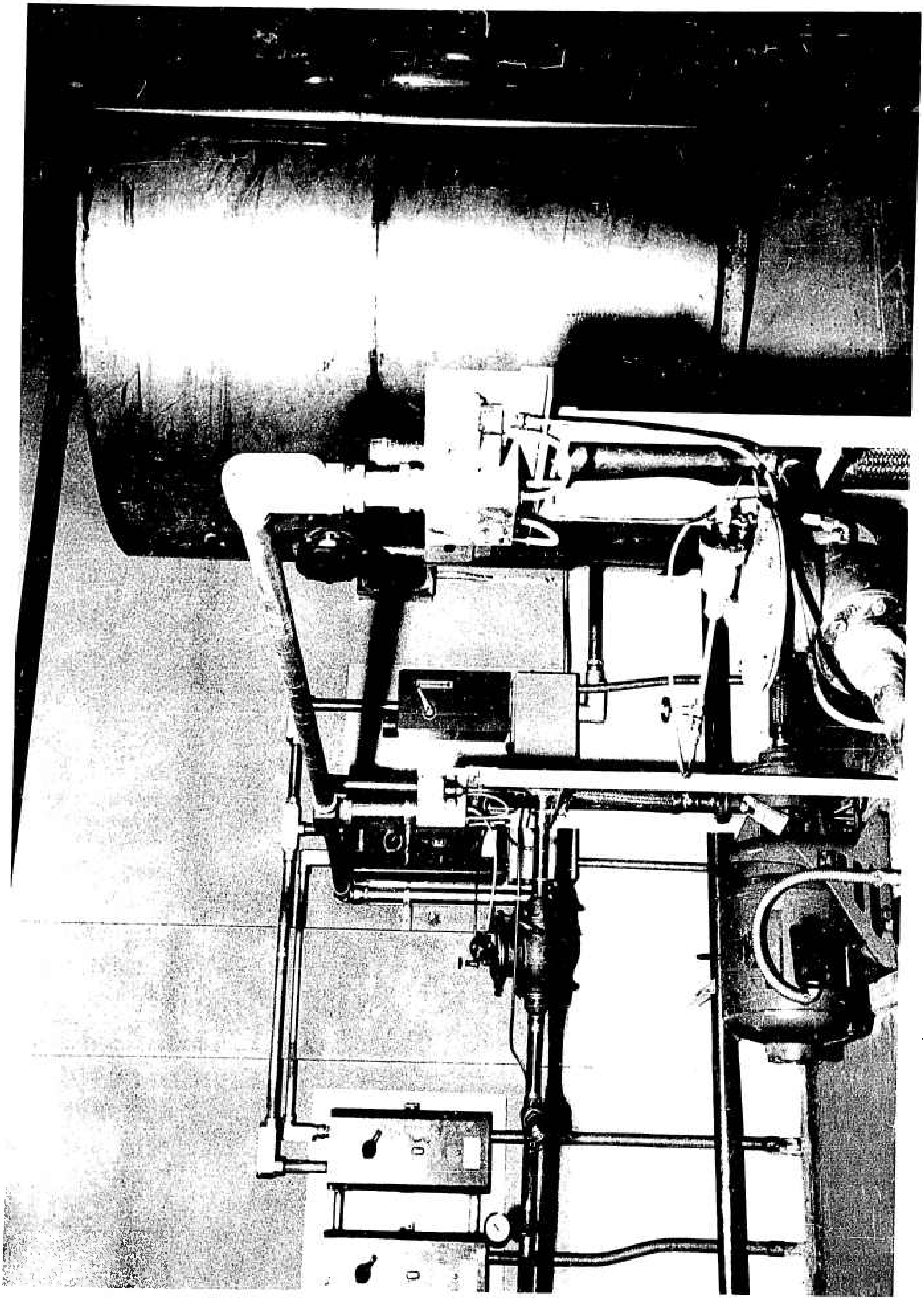


Figure 110. Pump Room.

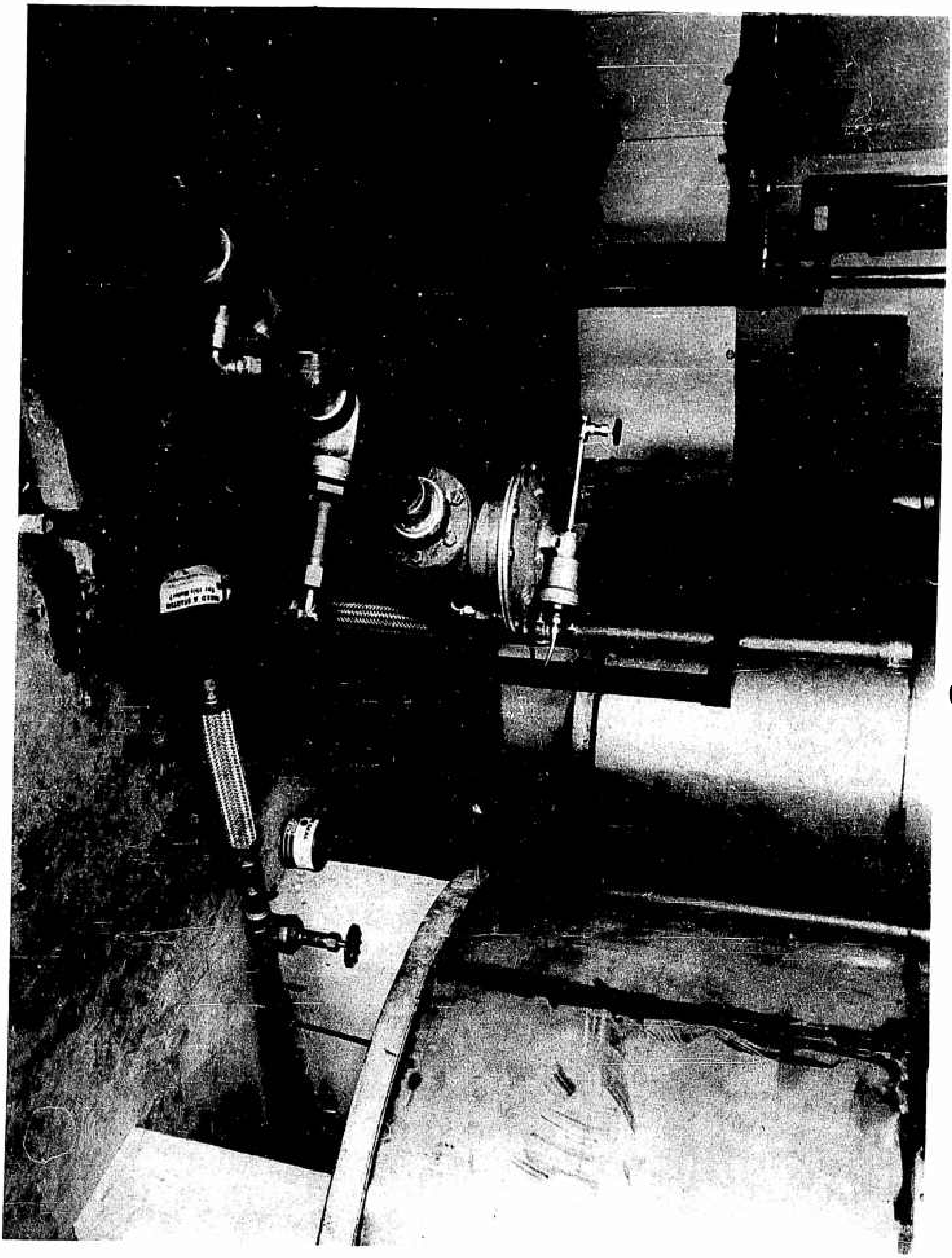


Figure 111. Pump Room, Showing Dummy Load Pump and Electric Water Valve Arrangement.

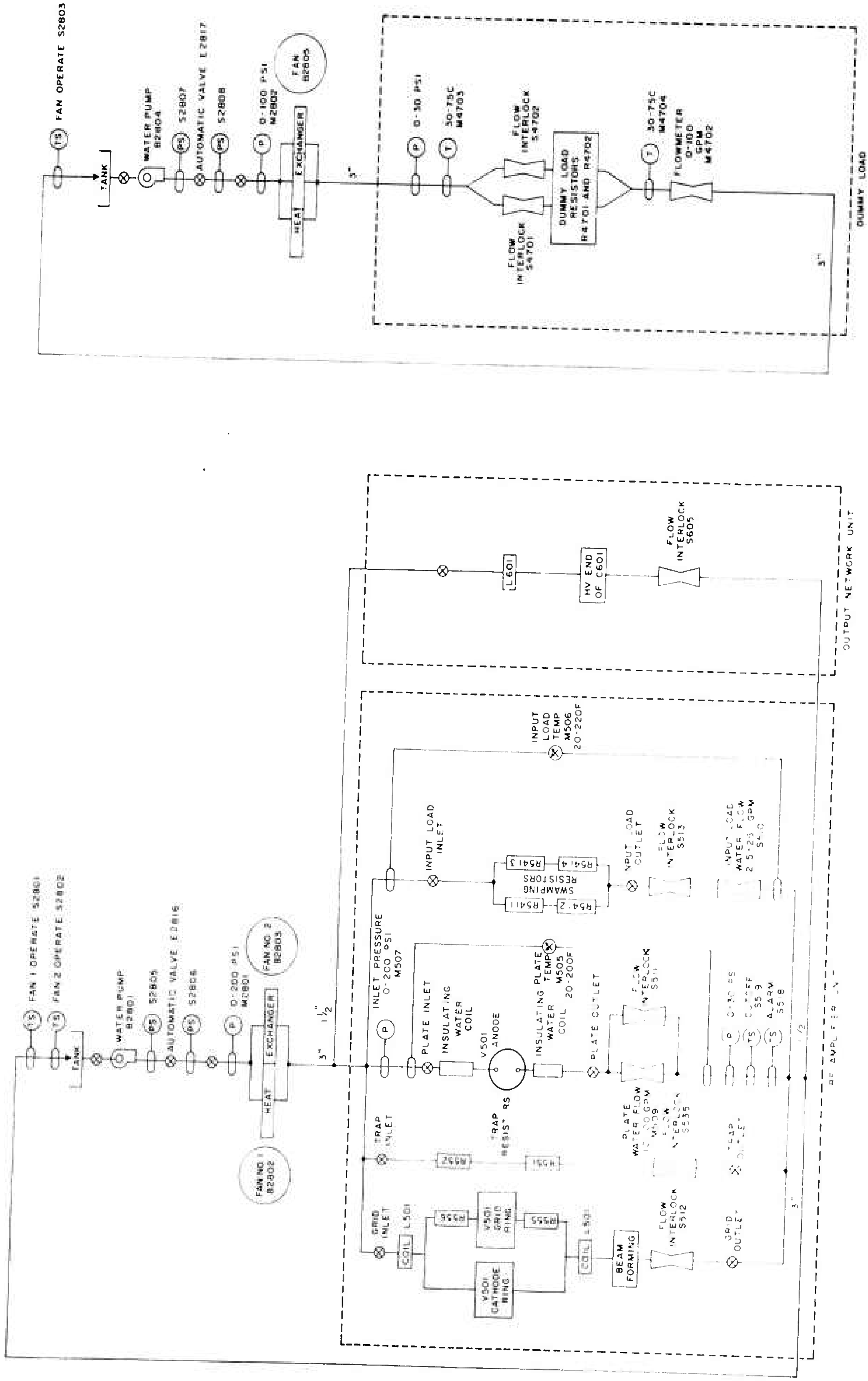


Figure 112. Hydraulic Schematic Diagram, Water Cooling System.

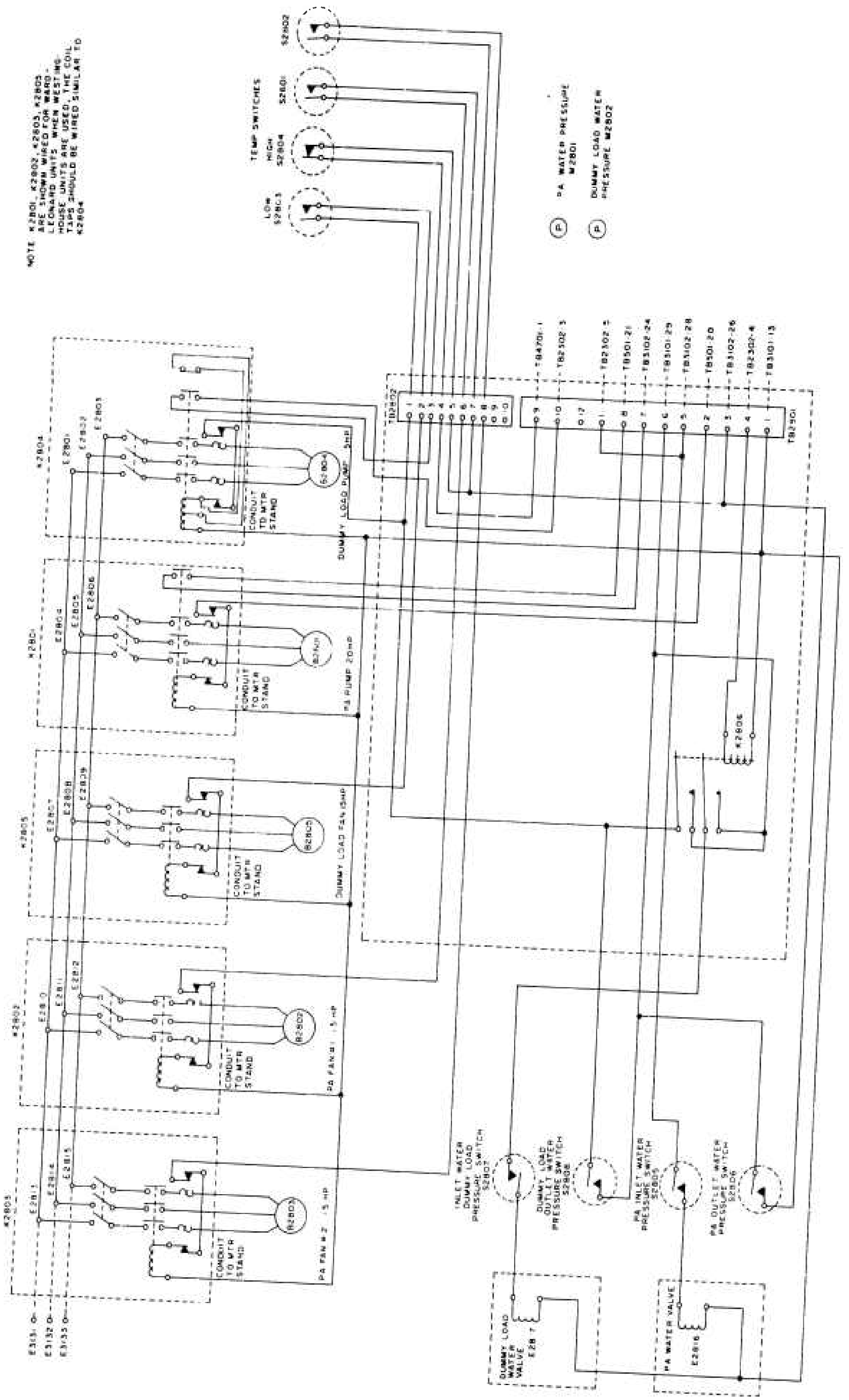


Figure 113. Schematic Diagram, Pump Room.

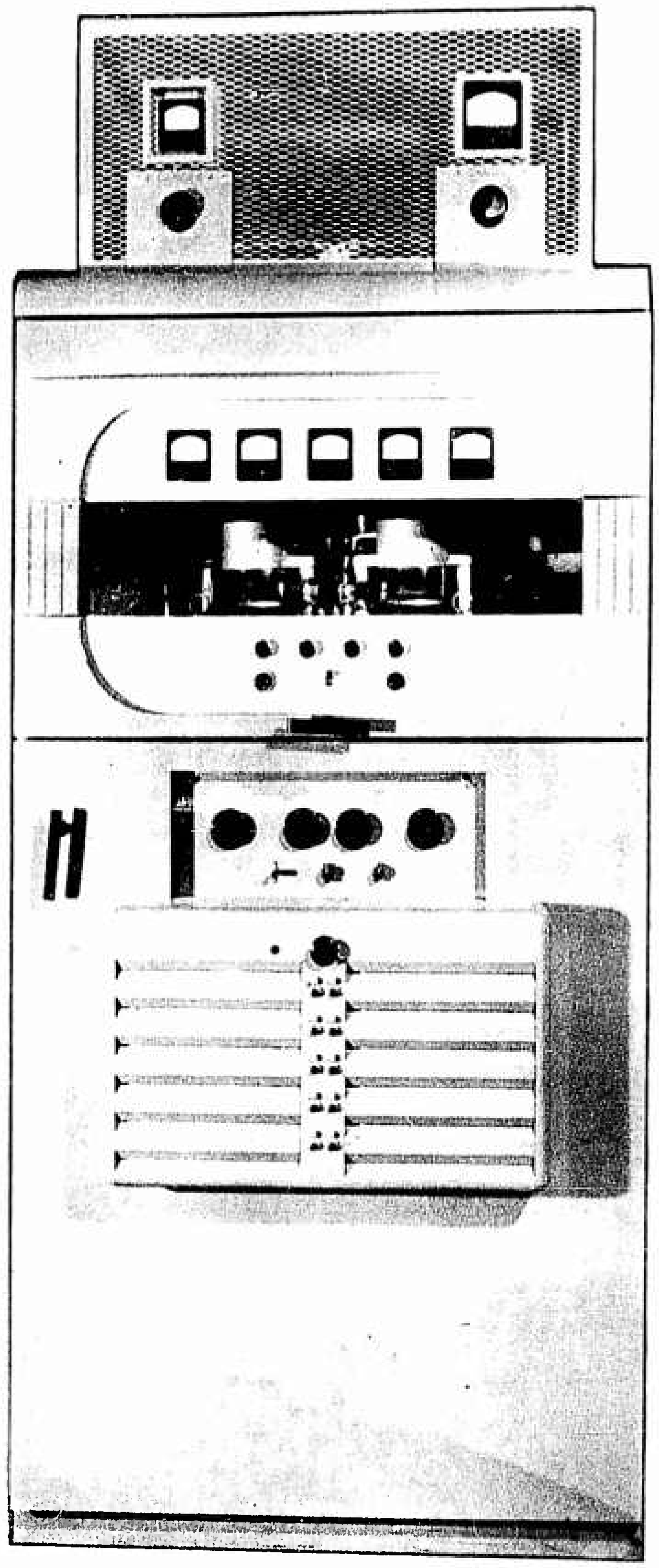


Figure 114. Radio Transmitter T-454/FRT-26 (Modified). Front View.

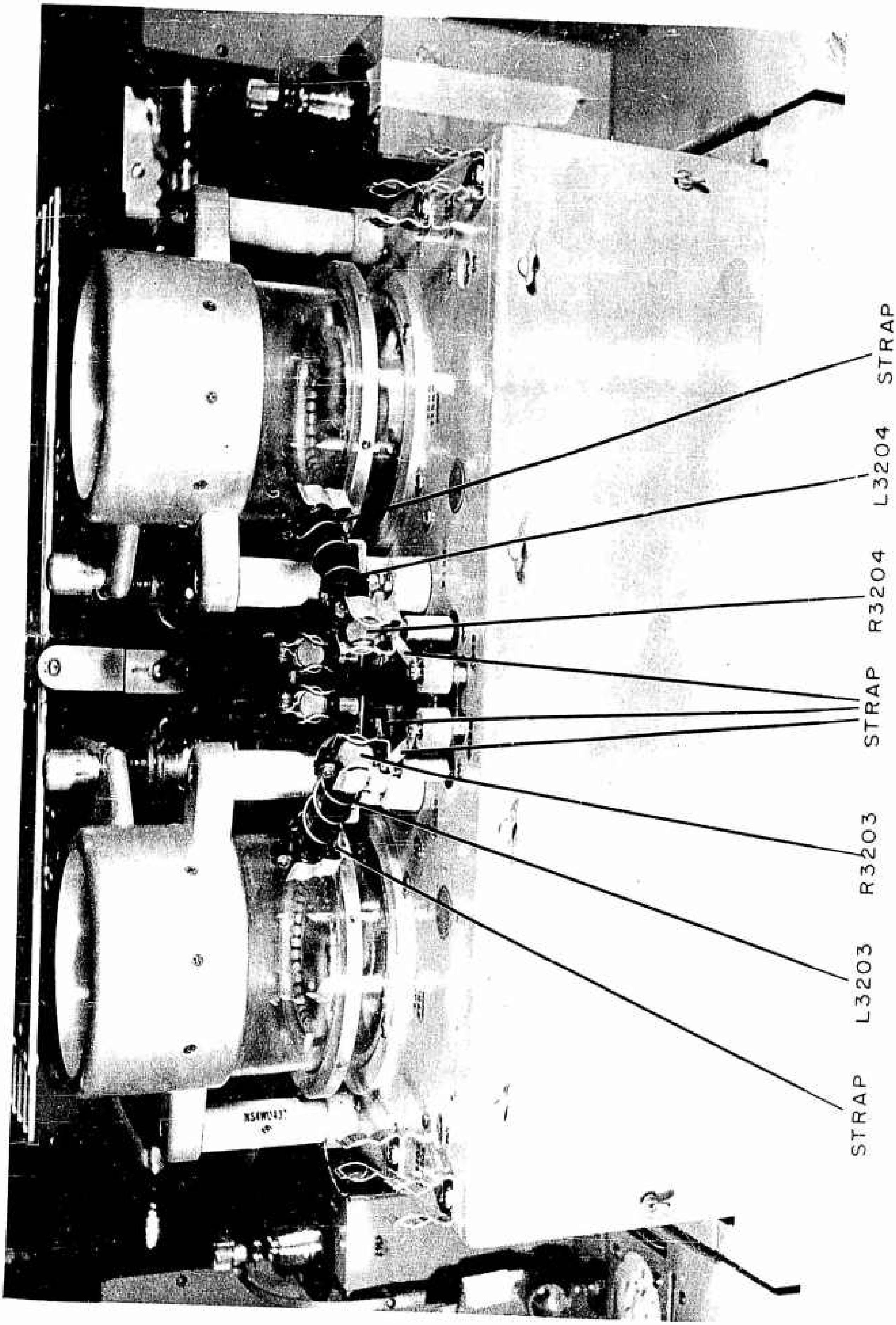


Figure 115. Radio Transmitter T-454/FRT-26 (Modified), PA Grid Box as Modified.

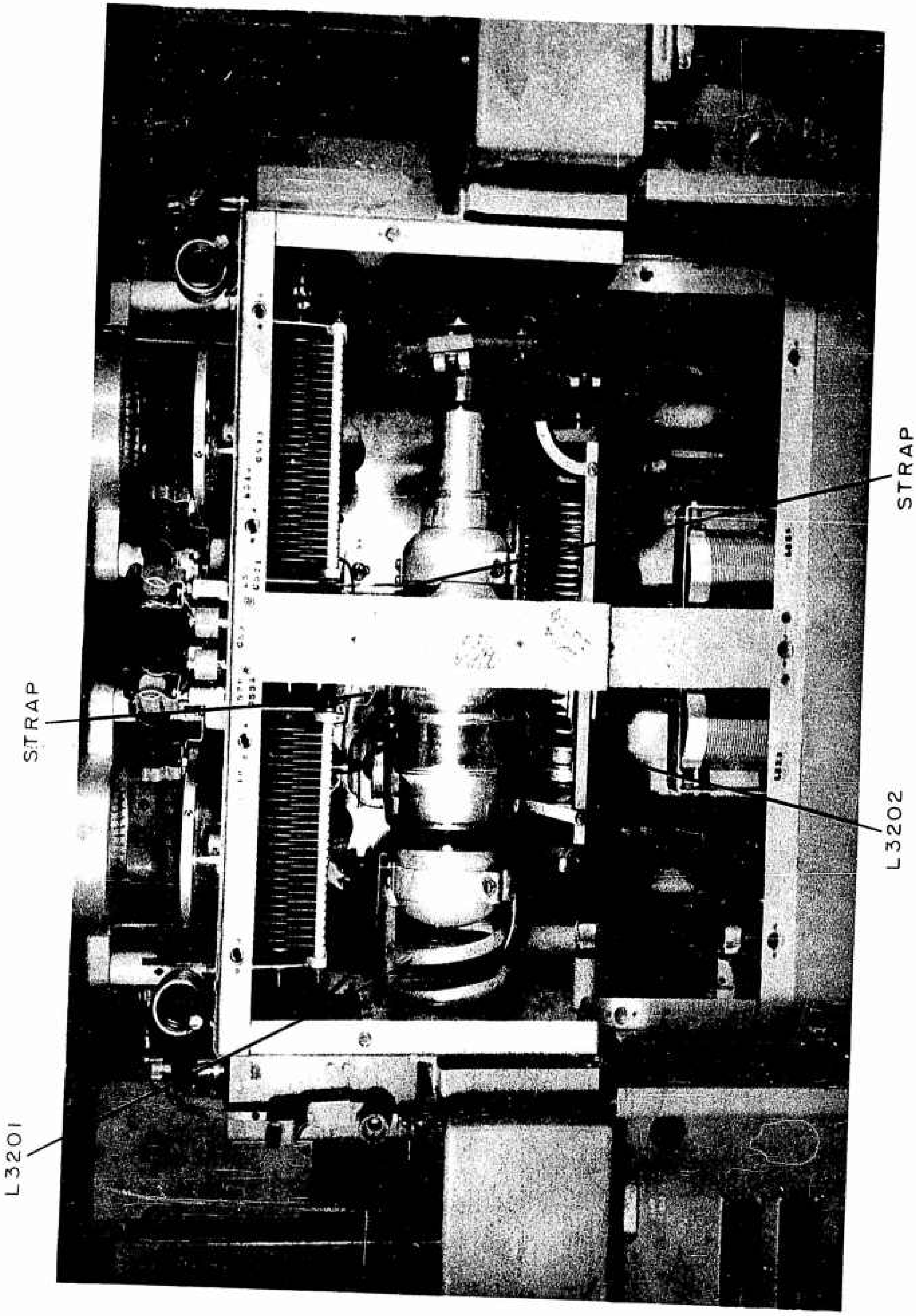


Figure 116. Radio Transmitter T-454/FRT-26 (Modified), Interior of PA Grid Box.

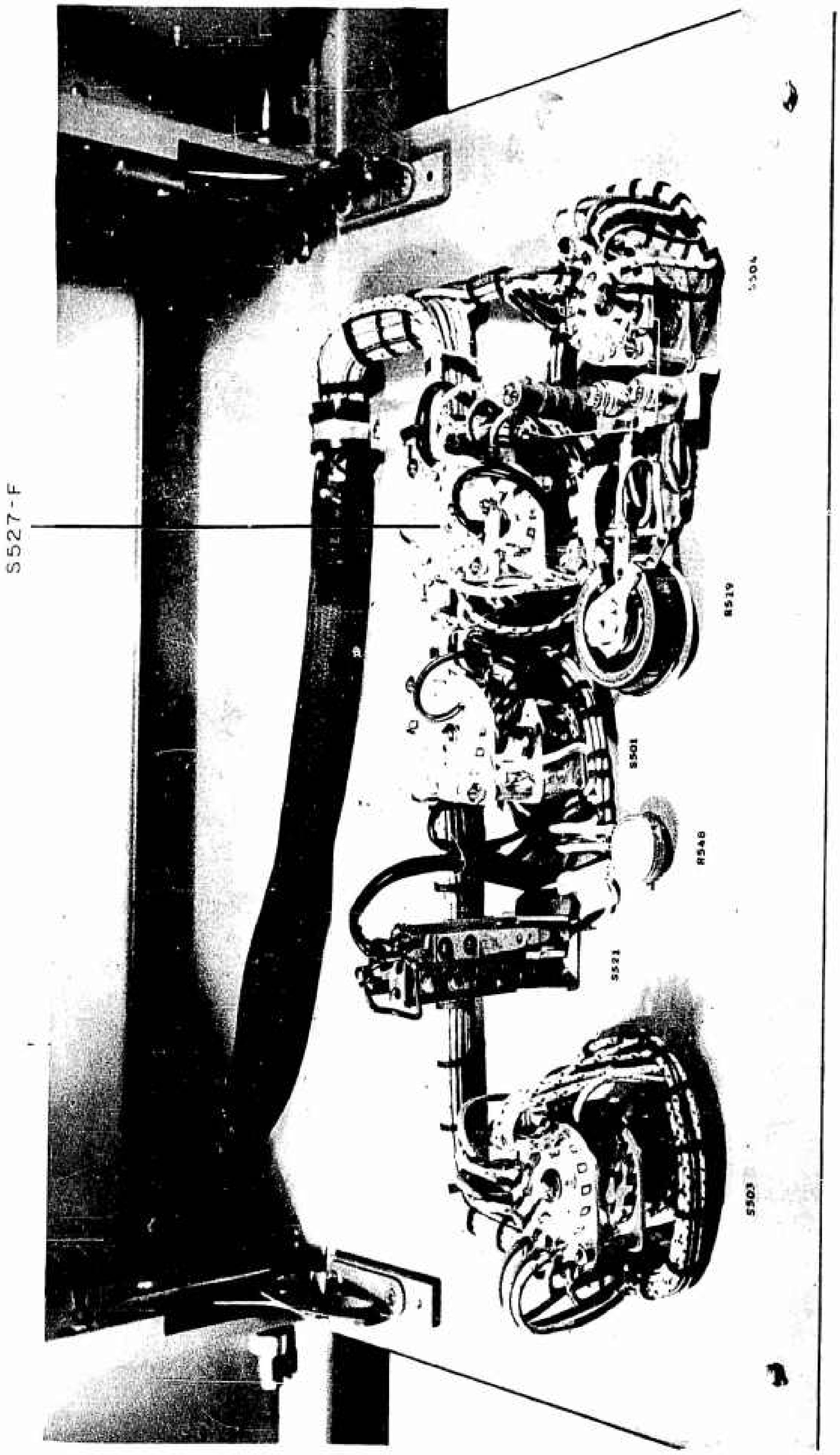


Figure 117. Radio Transmitter T-454/FRT-26 (Modified), Rear of Lower Control Panel.

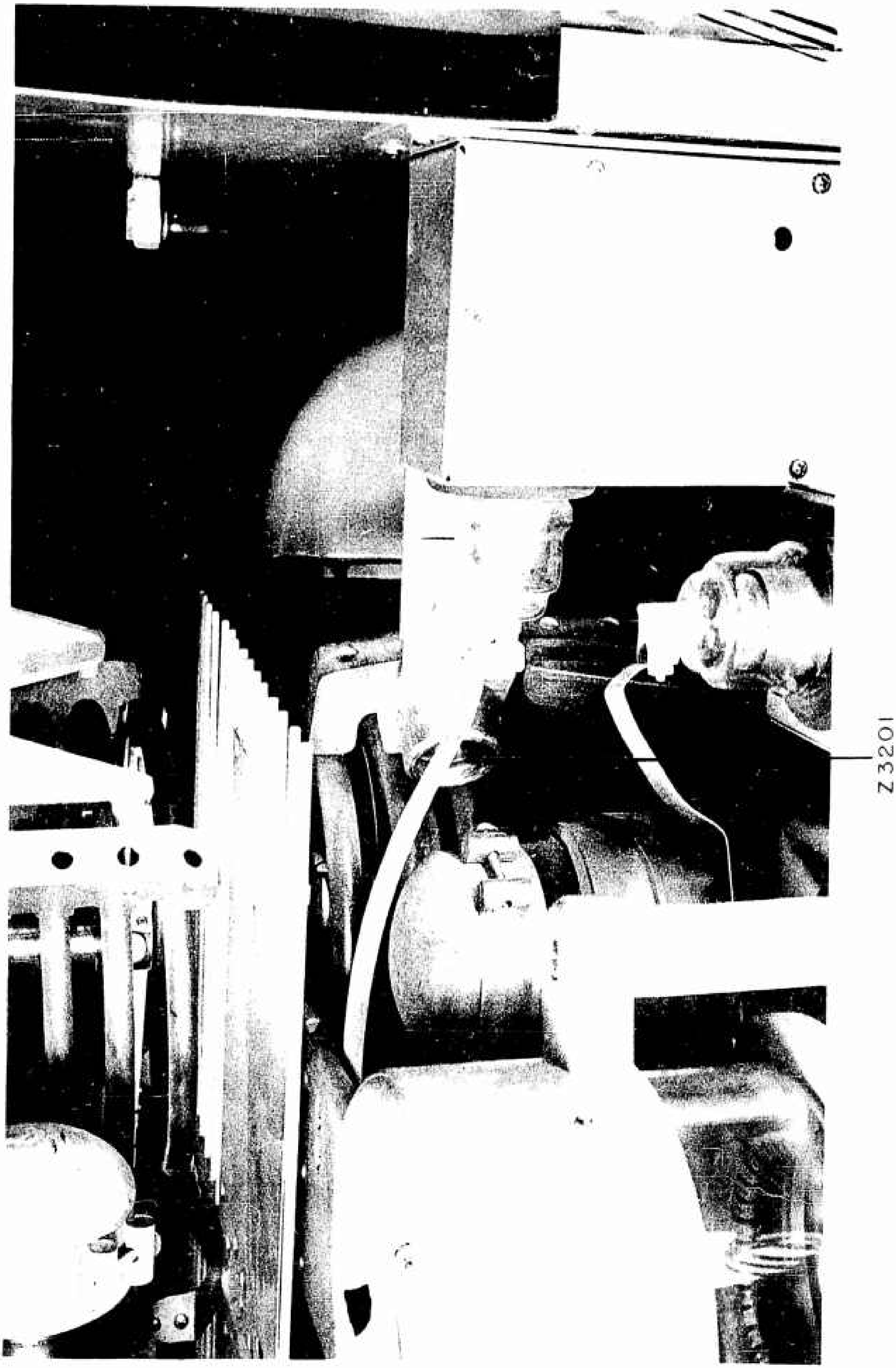


Figure 118. Radio Transmitter T-454/FRT-26 (Modified), Showing RF Sampling Probe Z3201.

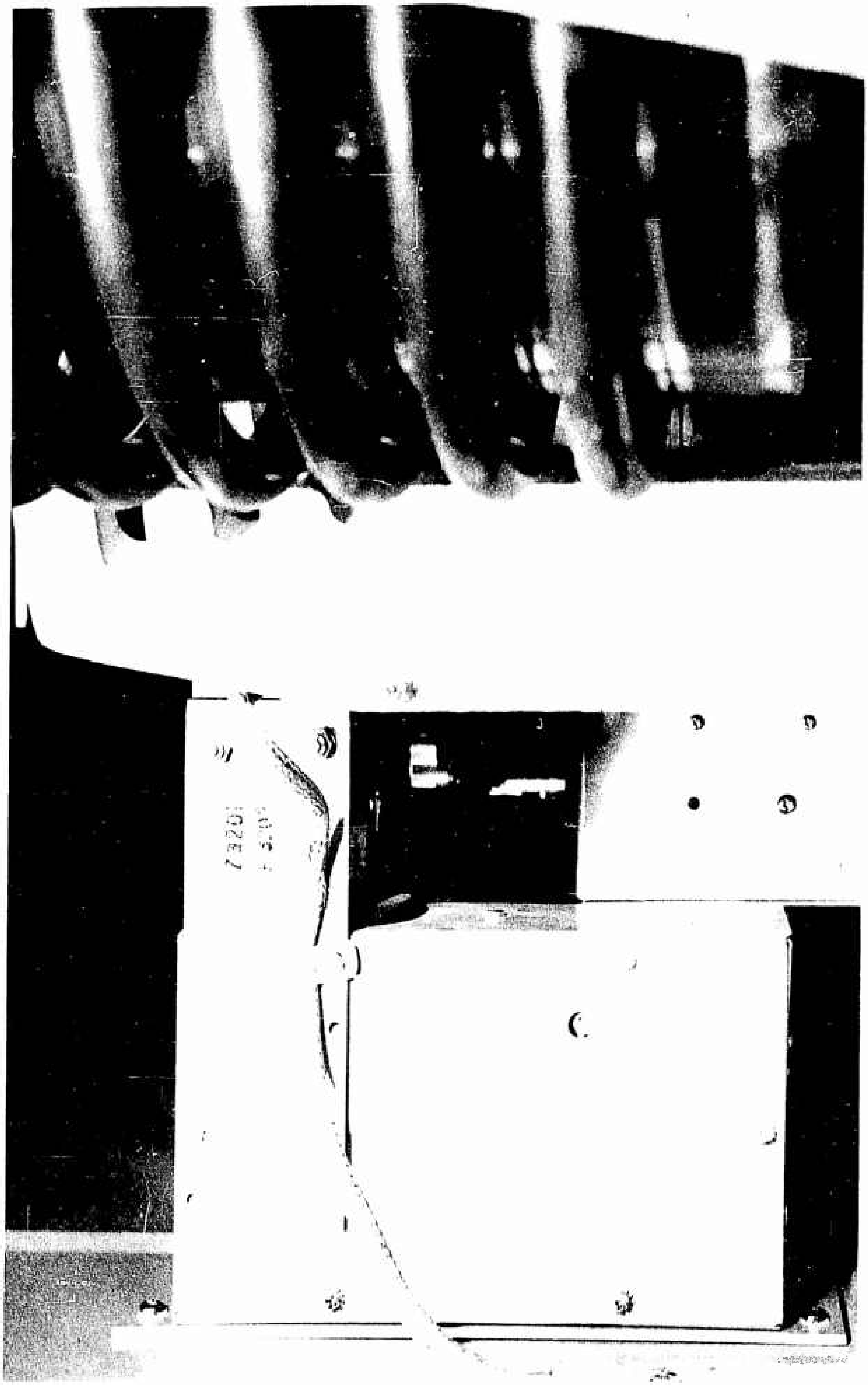


Figure 119. Radio Transmitter T-454/FRT-26 (Modified), Showing Mounting of Probe Z3201.

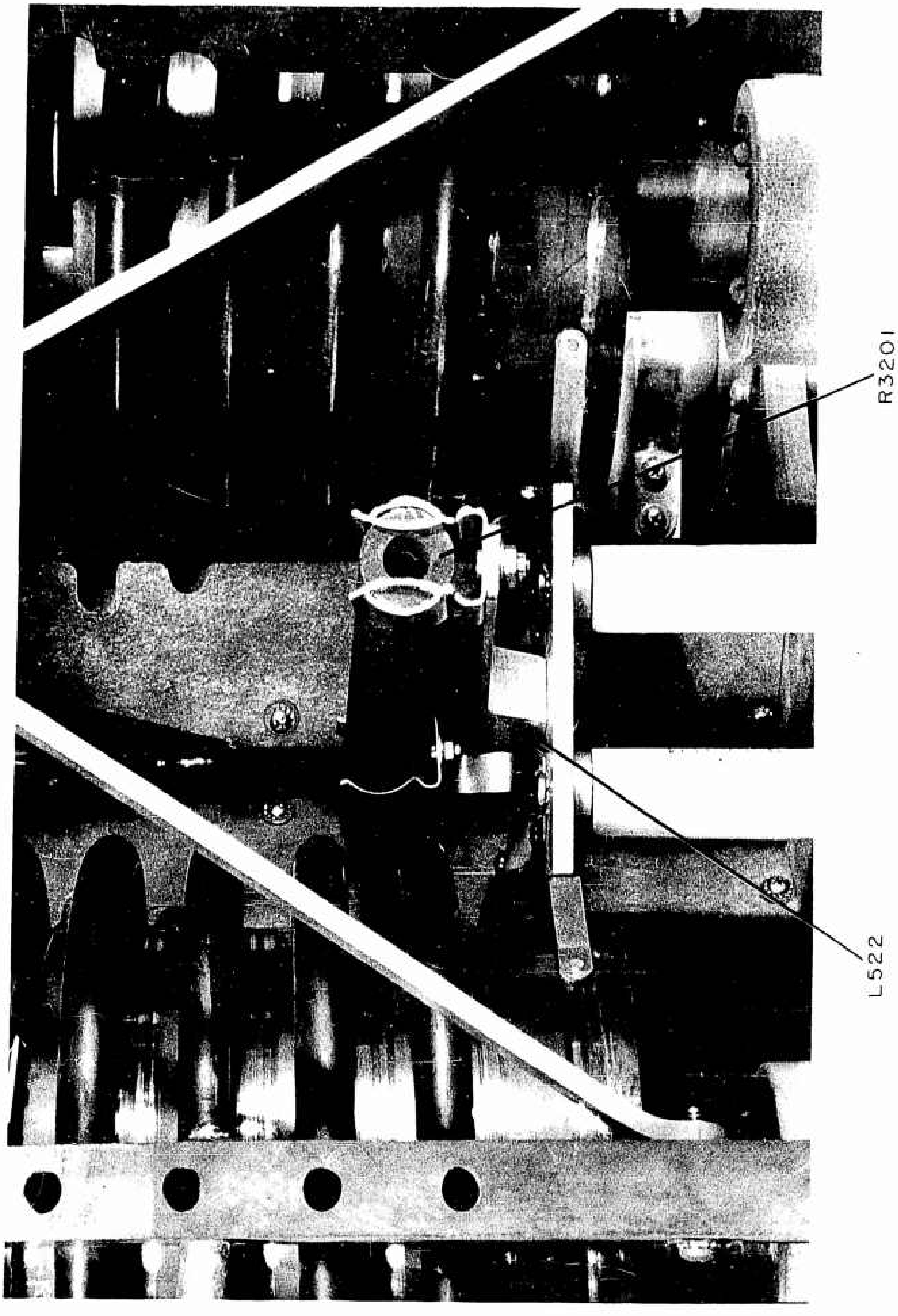


Figure 120. Radio Transmitter T-454/FRT-26 (Modified), Rear Detail of PA Plate Circuit.

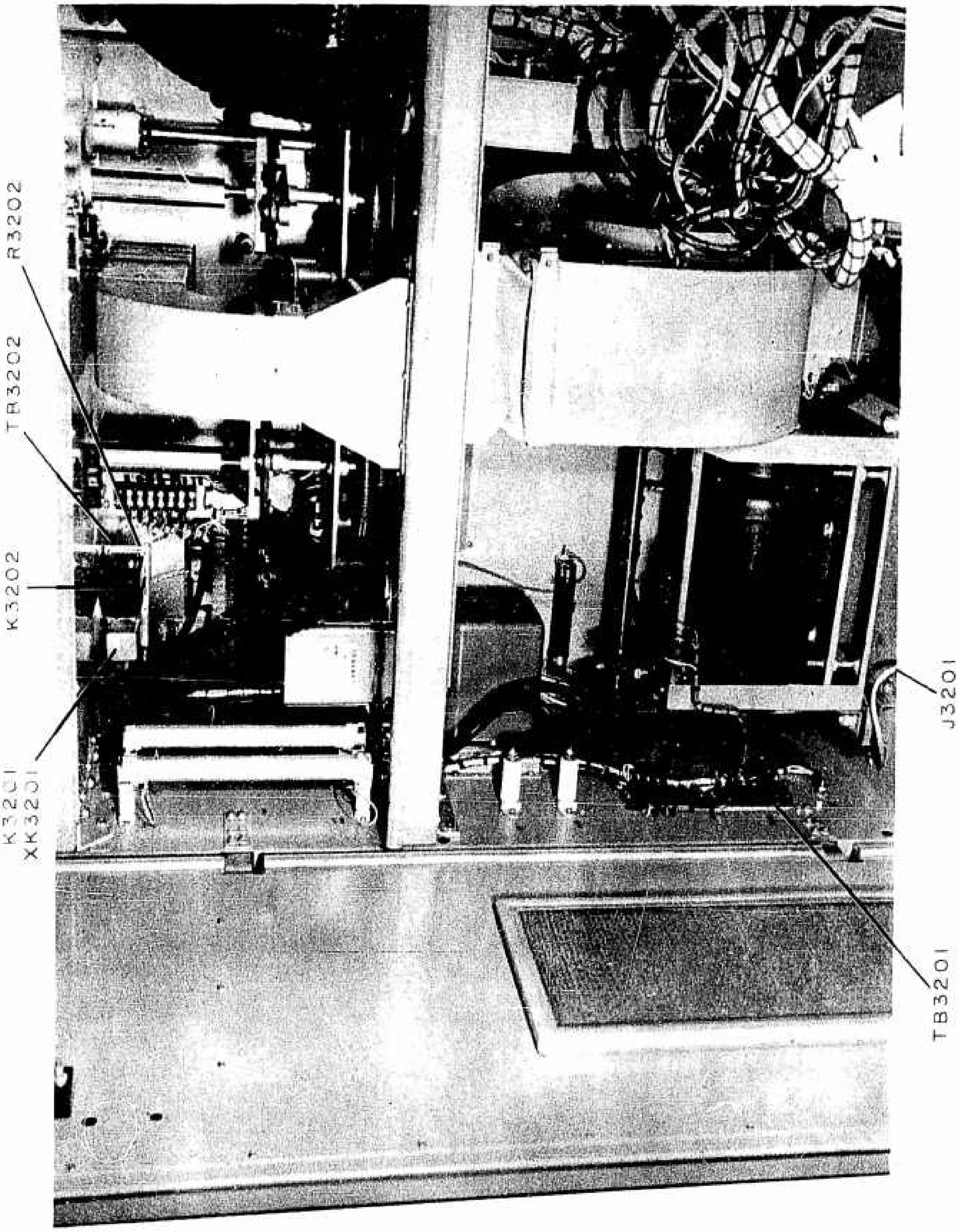


Figure 121. Radio Transmitter T-454/FRT-26 (Modified), Lower Rear.

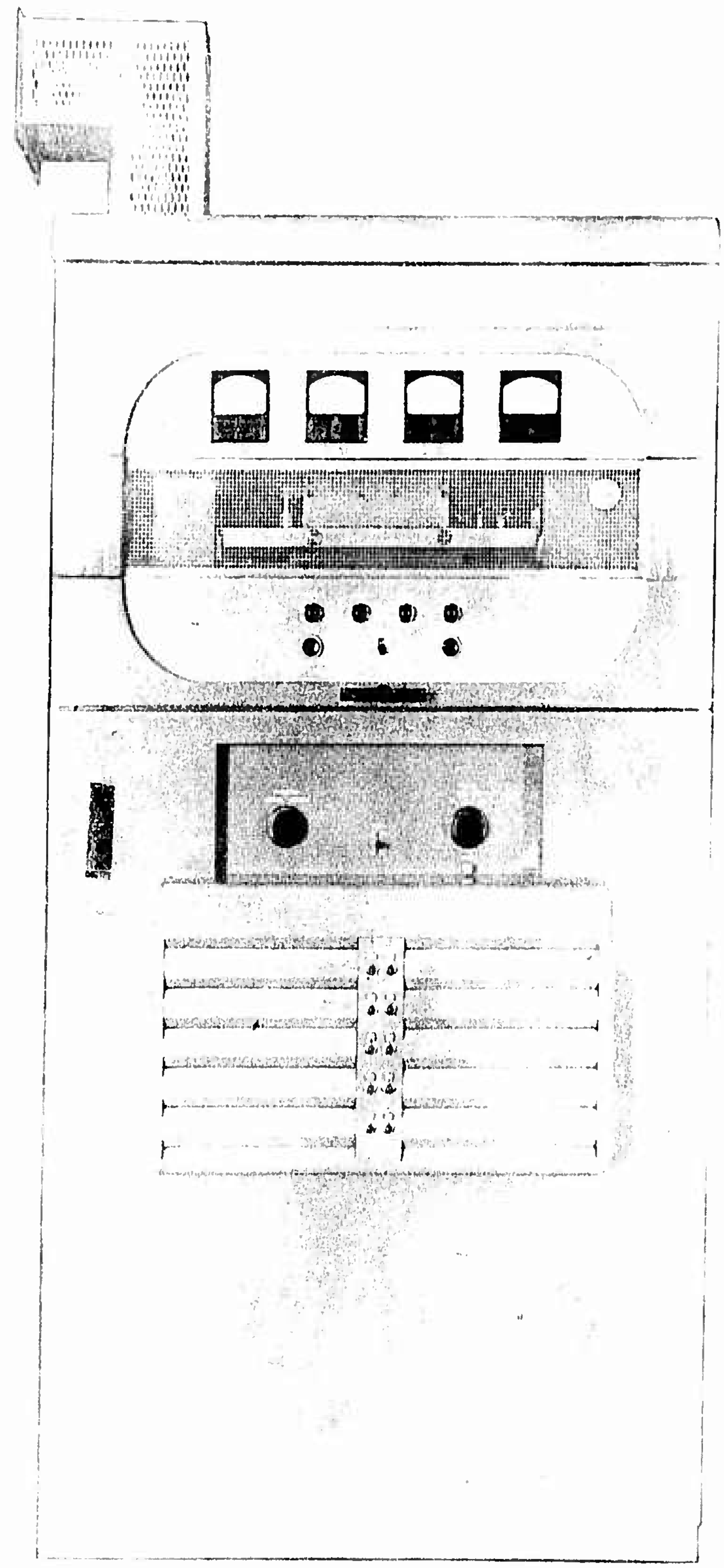


Figure 122. 40-Kw RF Amplifier, Front View.

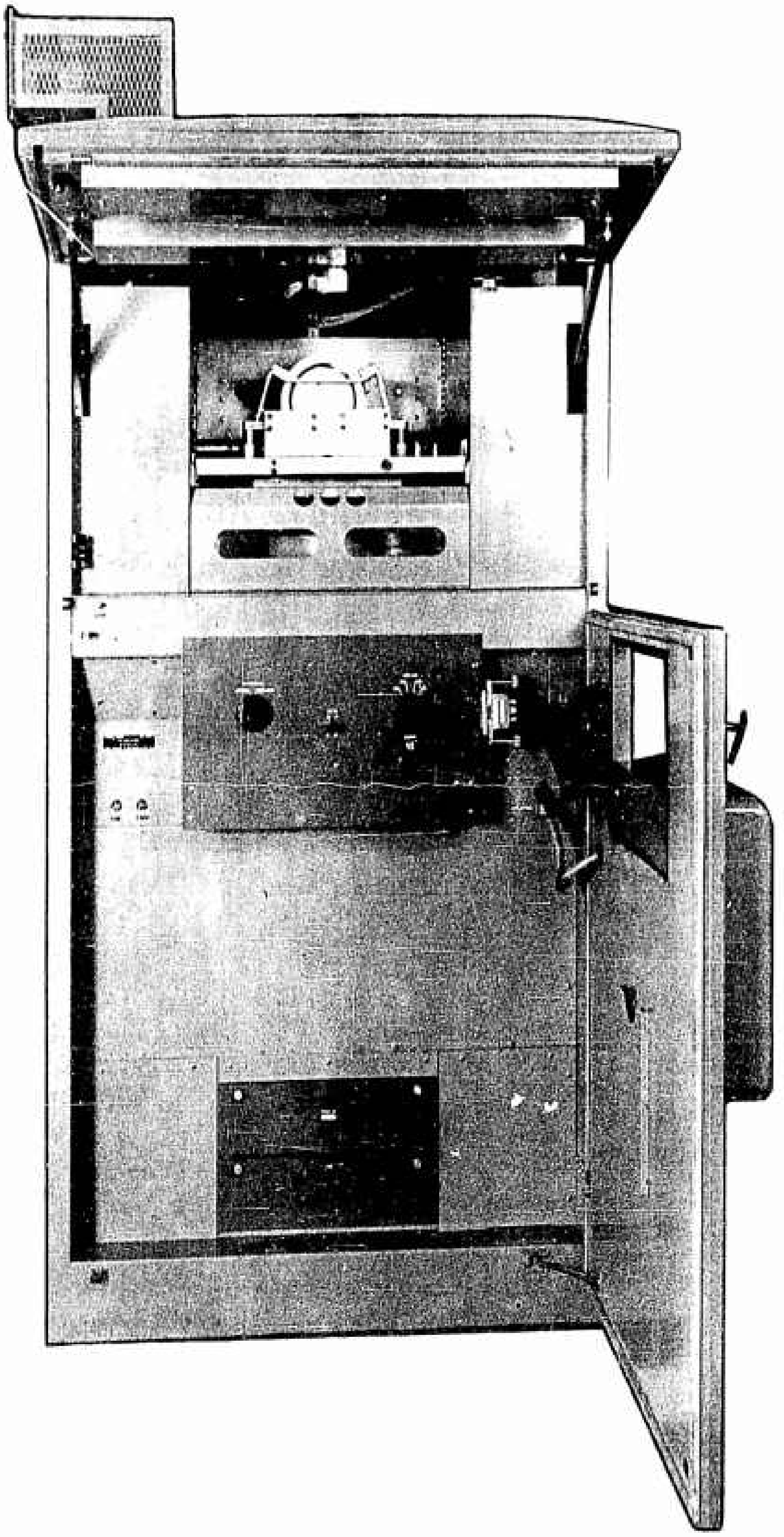


Figure 123. 40-Kw RF Amplifier, Front View, Doors Open

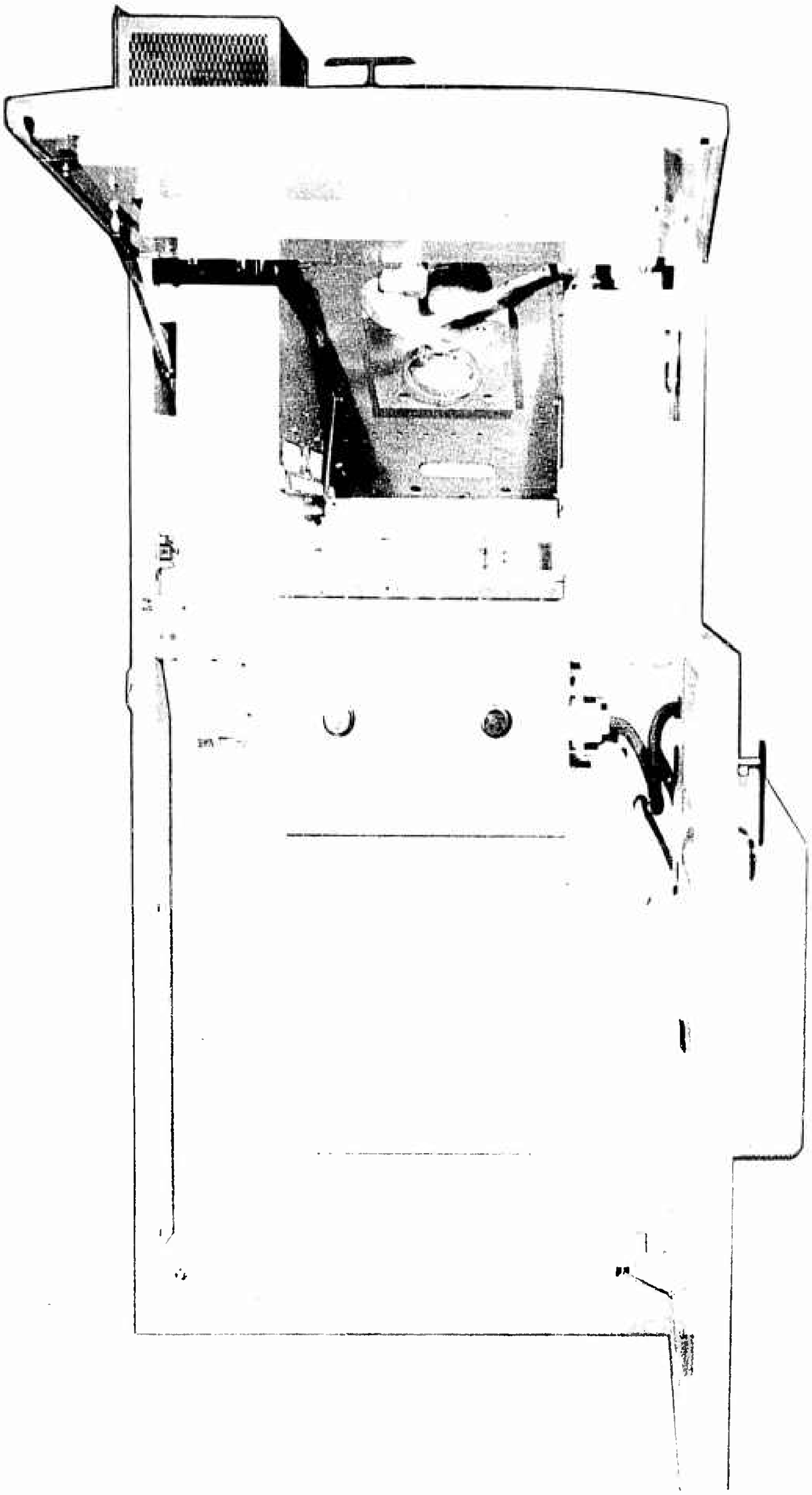


Figure 124. 40-Kw RF Amplifier, PA Tube Removed.

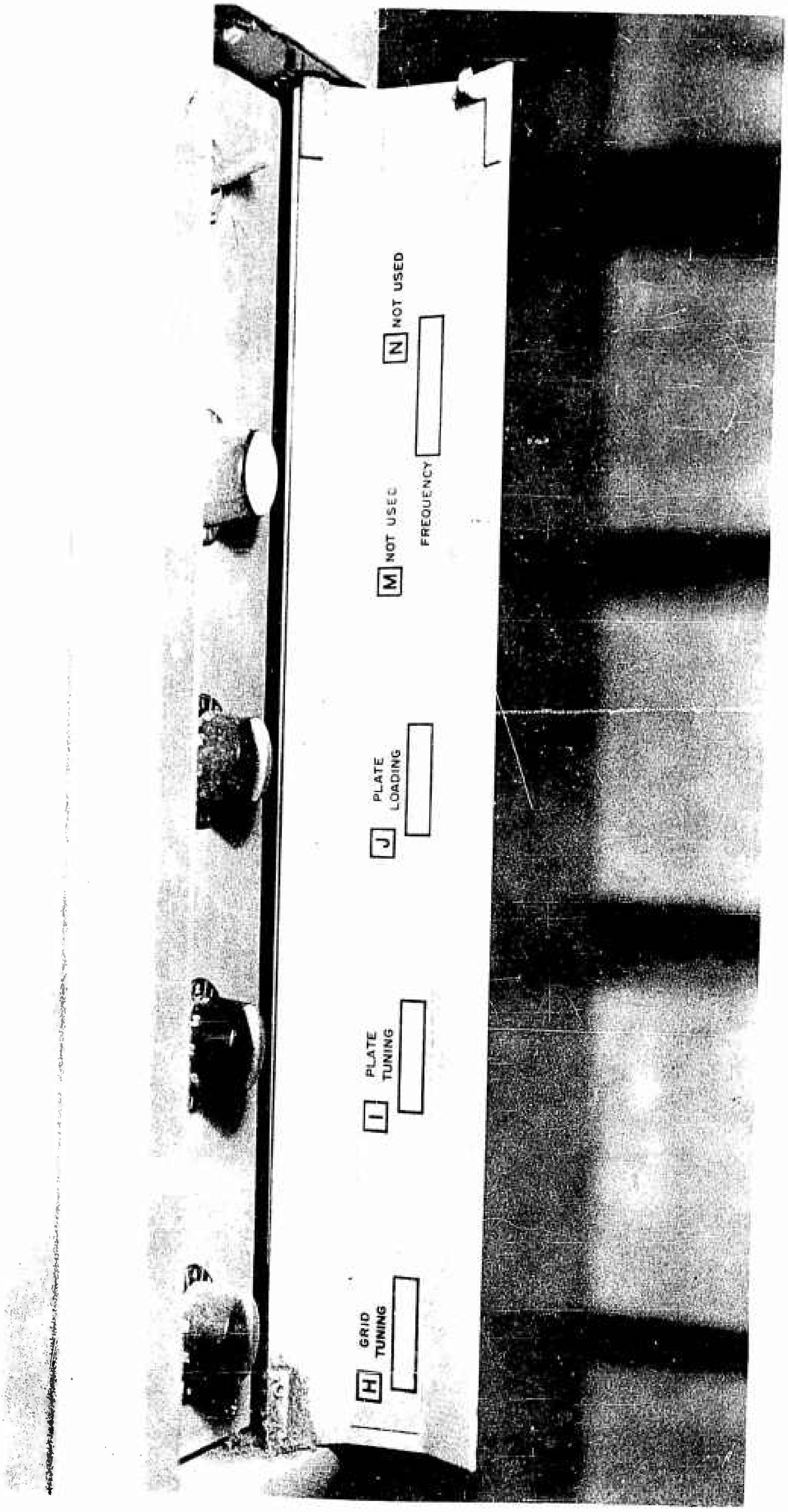


Figure 125. 40-Kw RF Amplifier, Servo Tuning Control Panel.

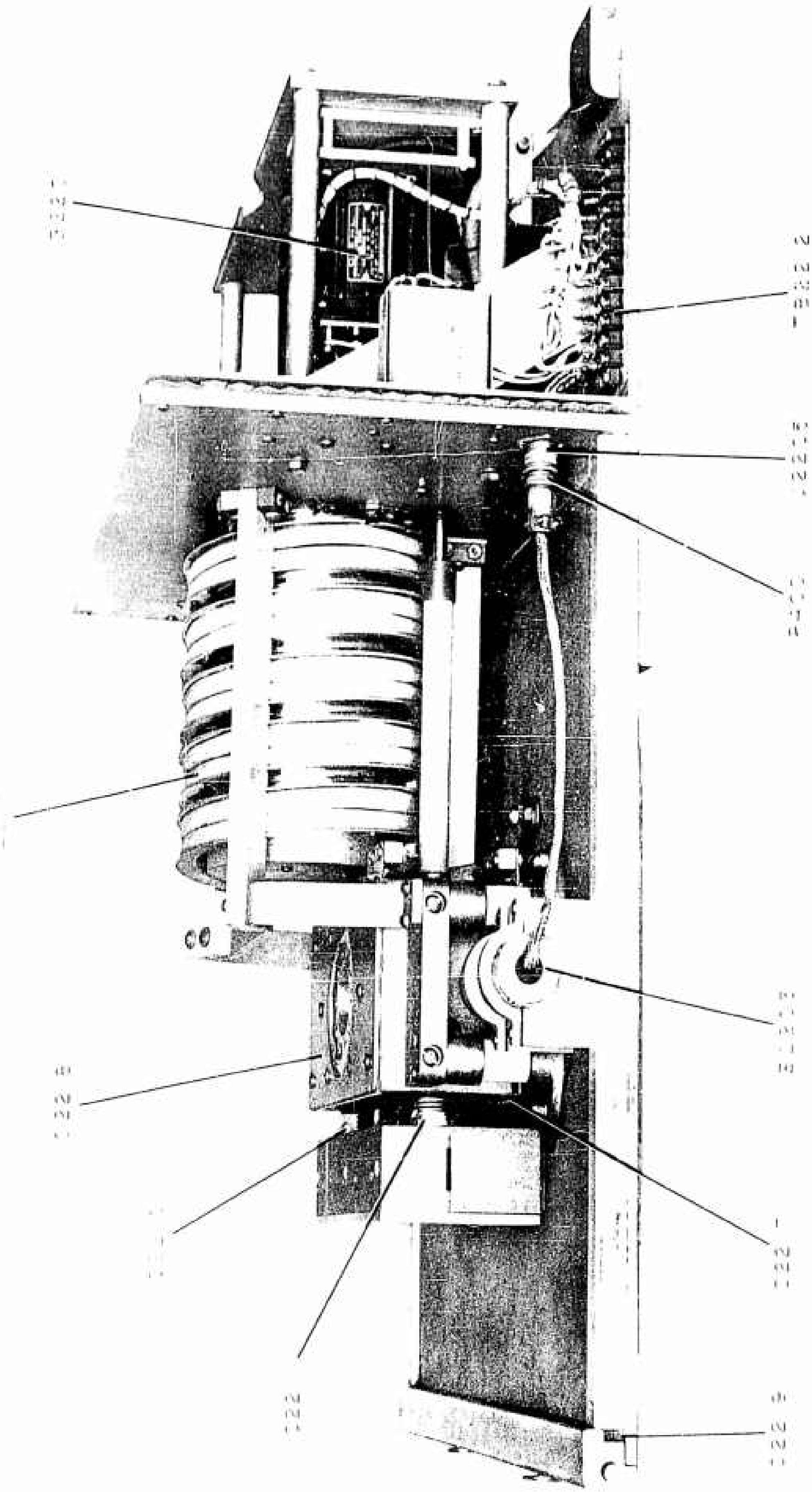


Figure 126. 40-Kw RF Amplifier Grid Shelf, Side View.

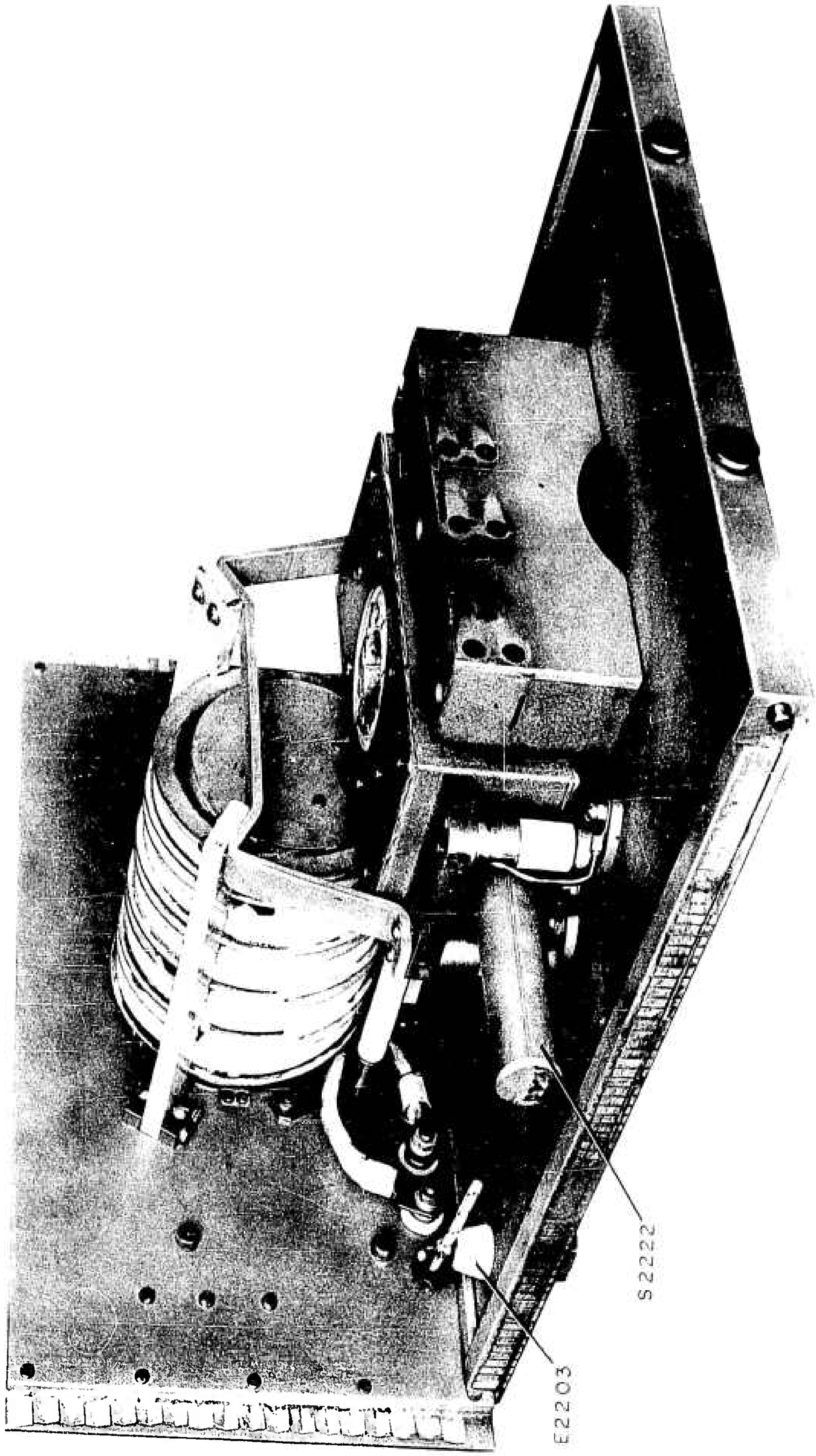


Figure 127 40-Kw RF Amplifier Grid Shelf, Oblique View.

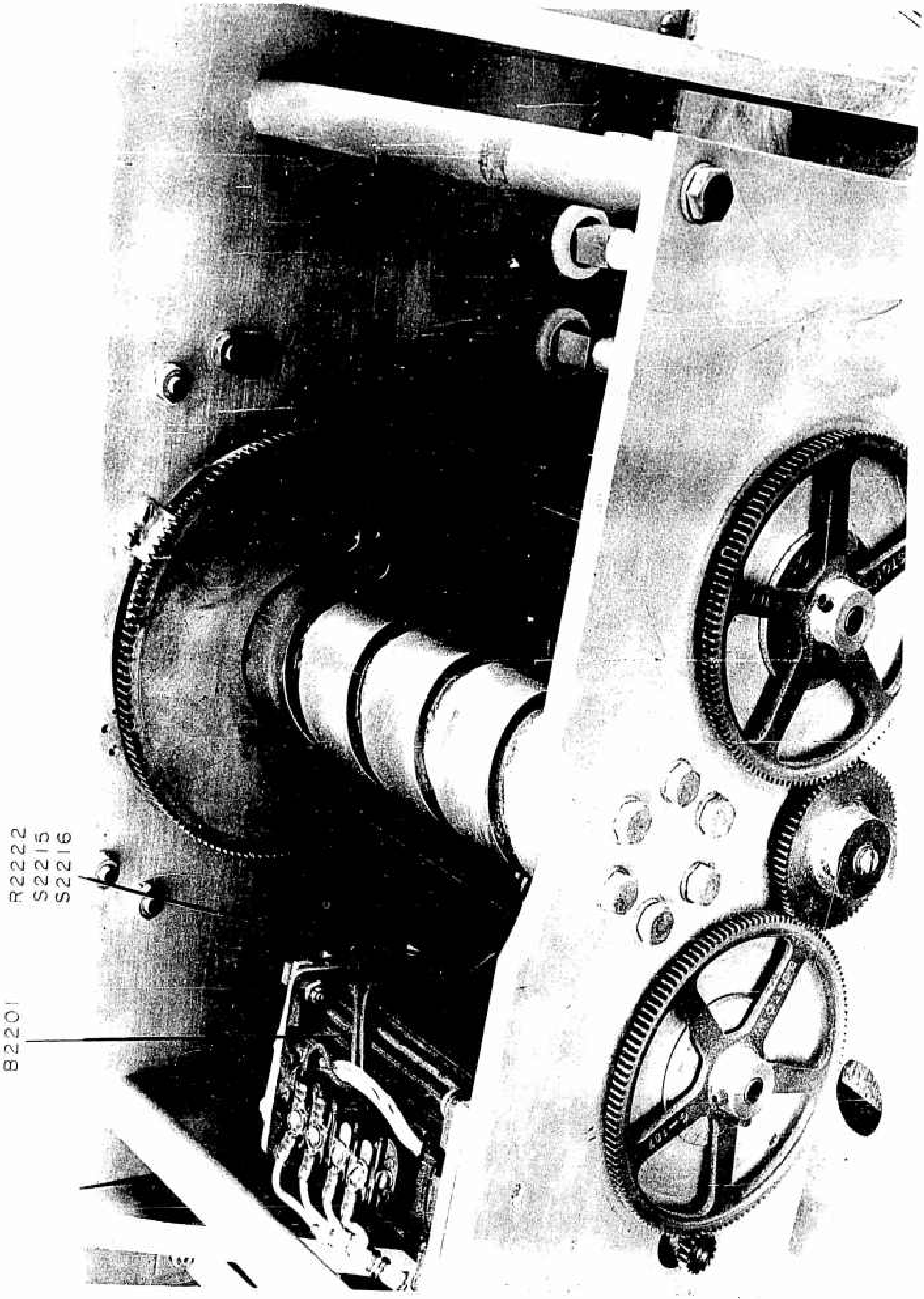


Figure 128. 40-Kw RF Amplifier Grid Shelf Tuning Drive Assembly.

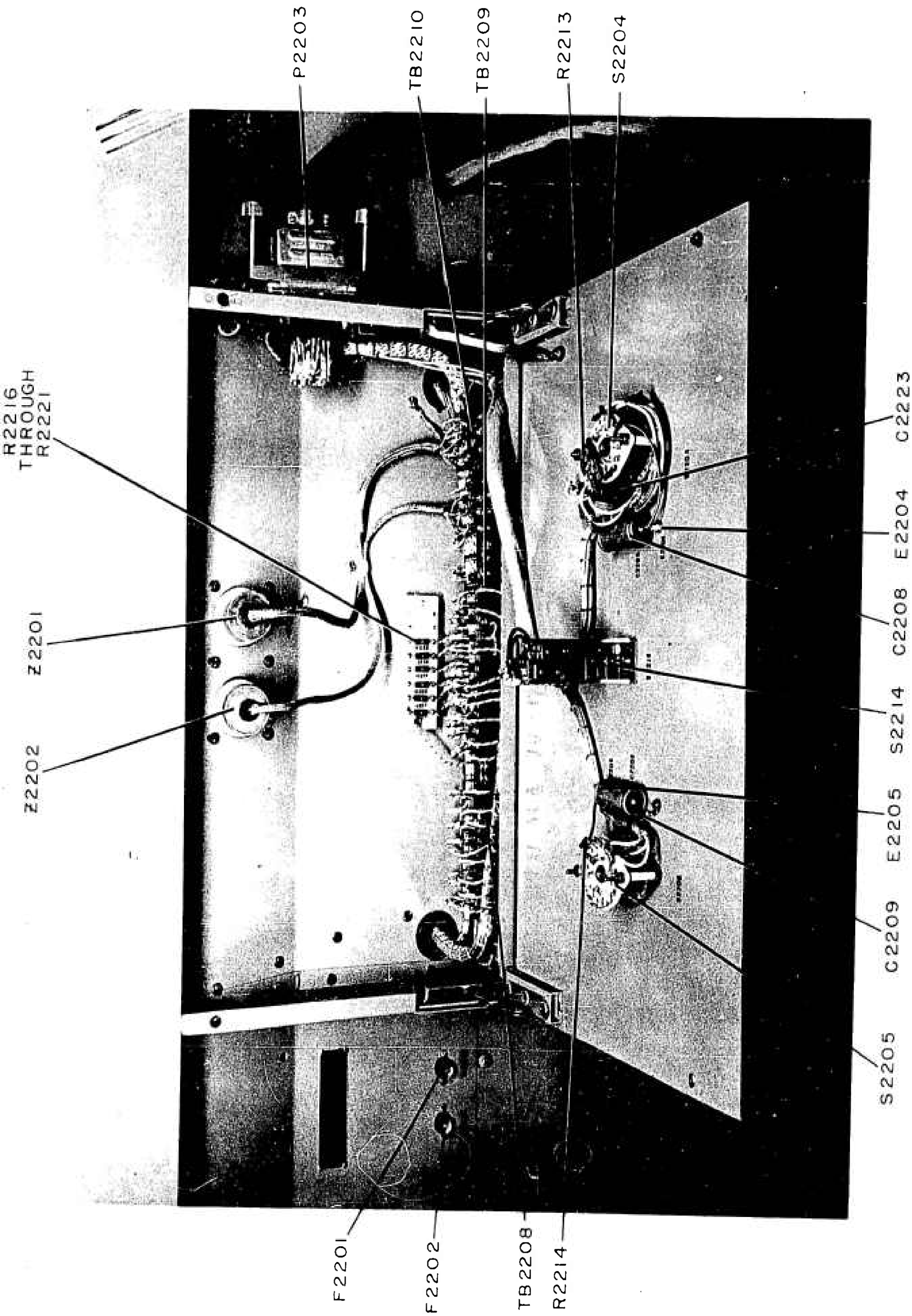


Figure 129. 40-Kw RF Amplifier, Front Detail with Control Panel Open.

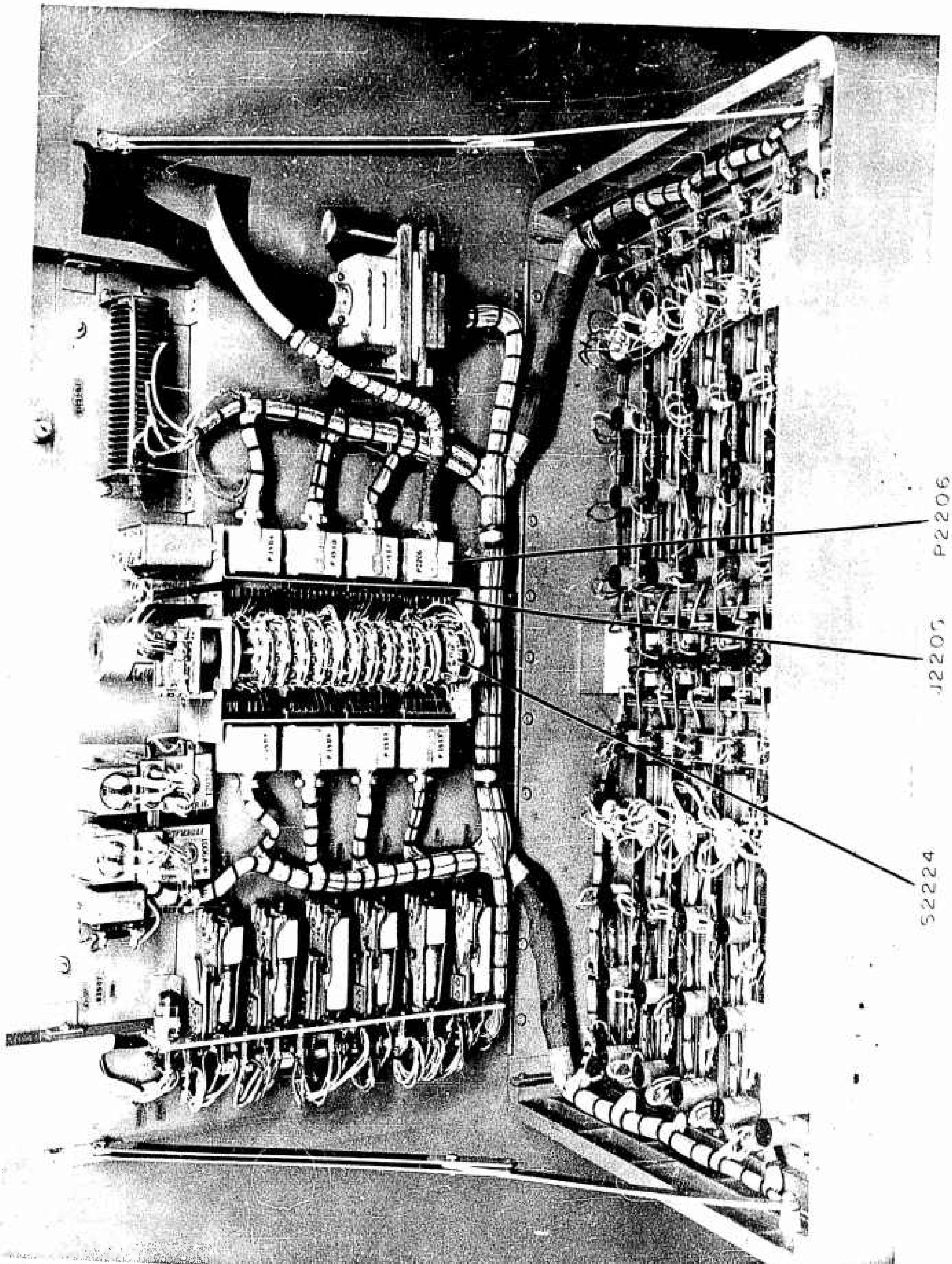


Figure 130. 40-Kw RF Amplifier Servo Tuning Control Section, with Control Panel Open.

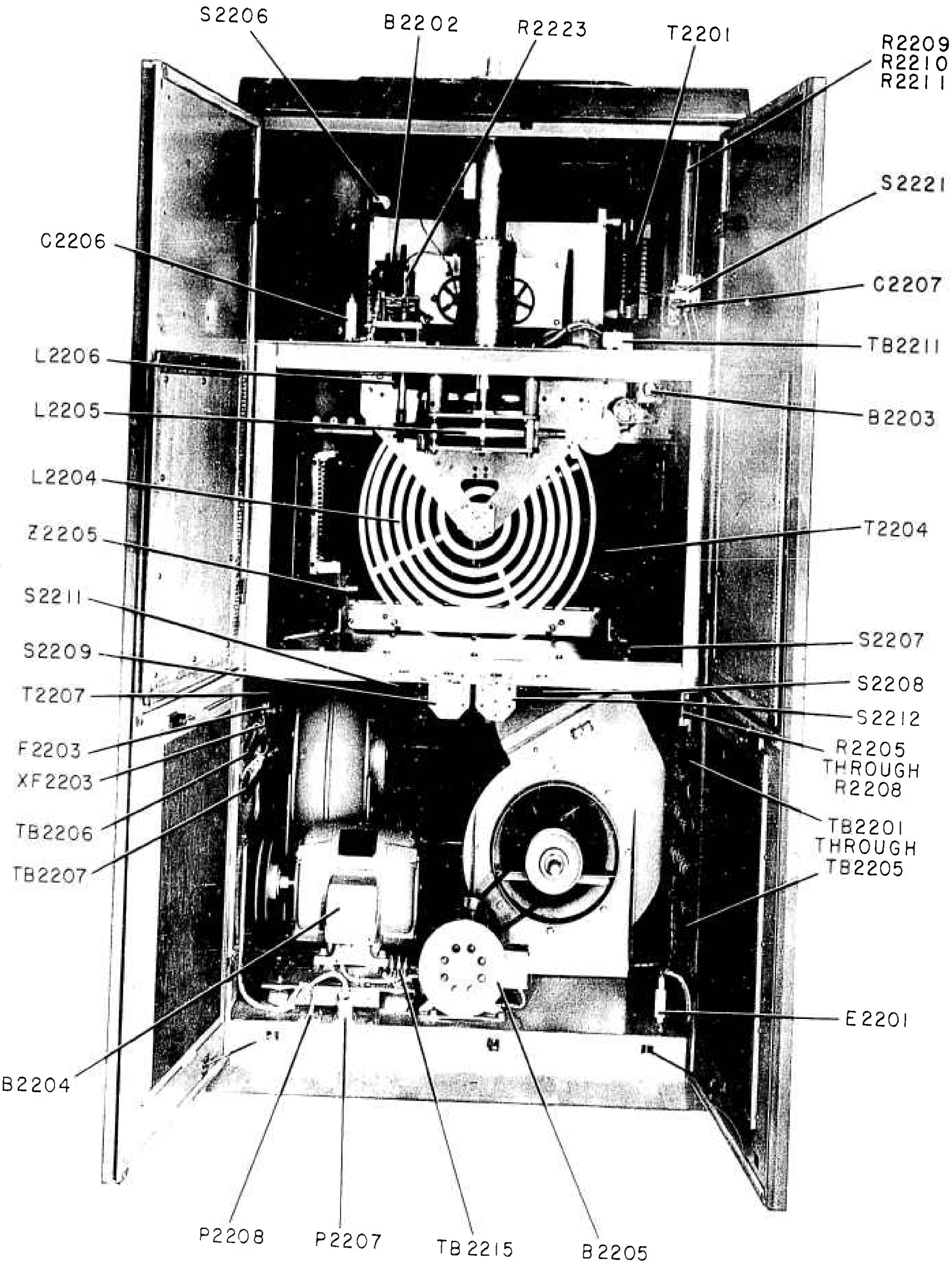


Figure 131. 40-Kw RF Amplifier, Rear View, Doors Open.

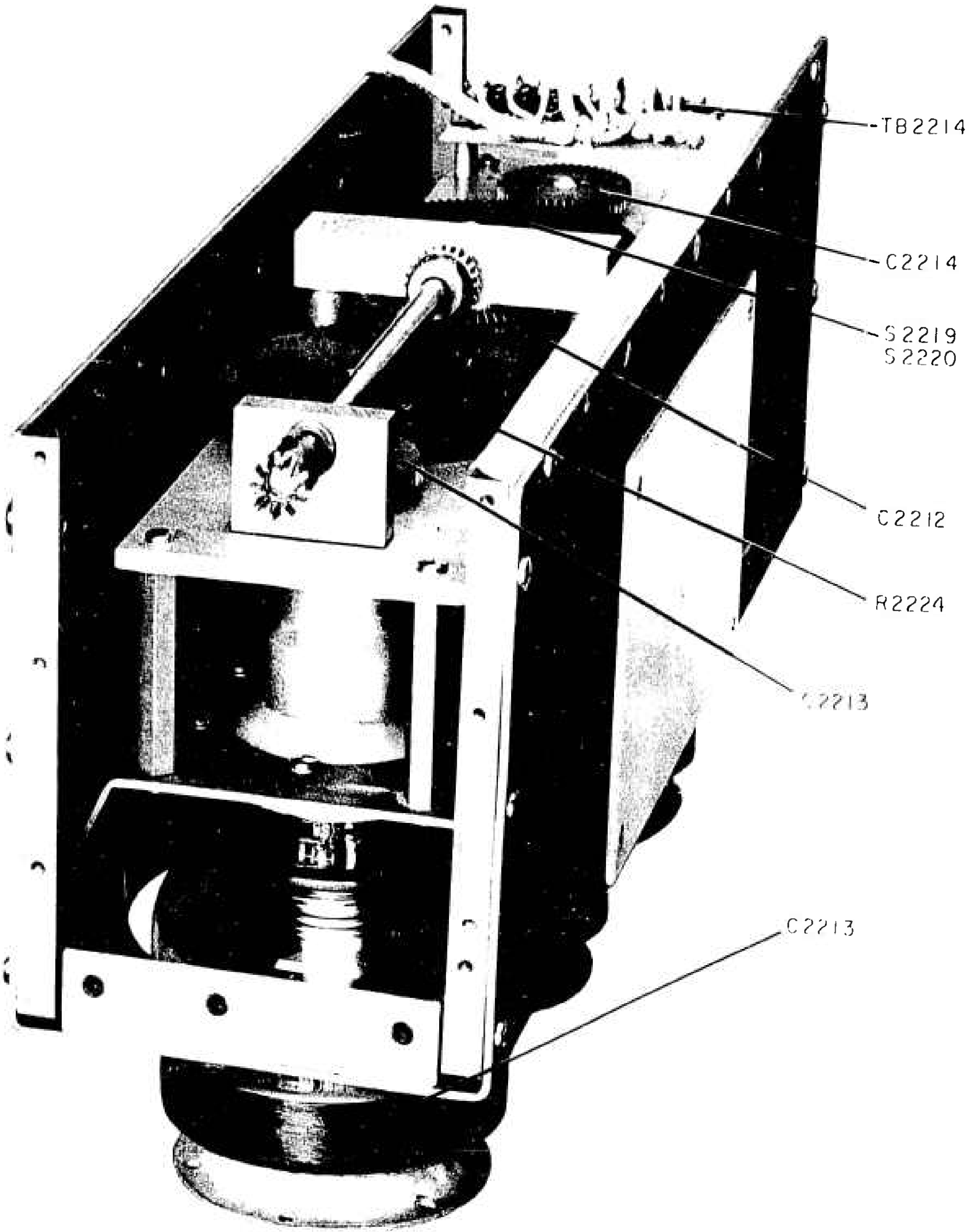


Figure 132. 40-Kw RF Amplifier Plate Tuning Capacitor Assembly.

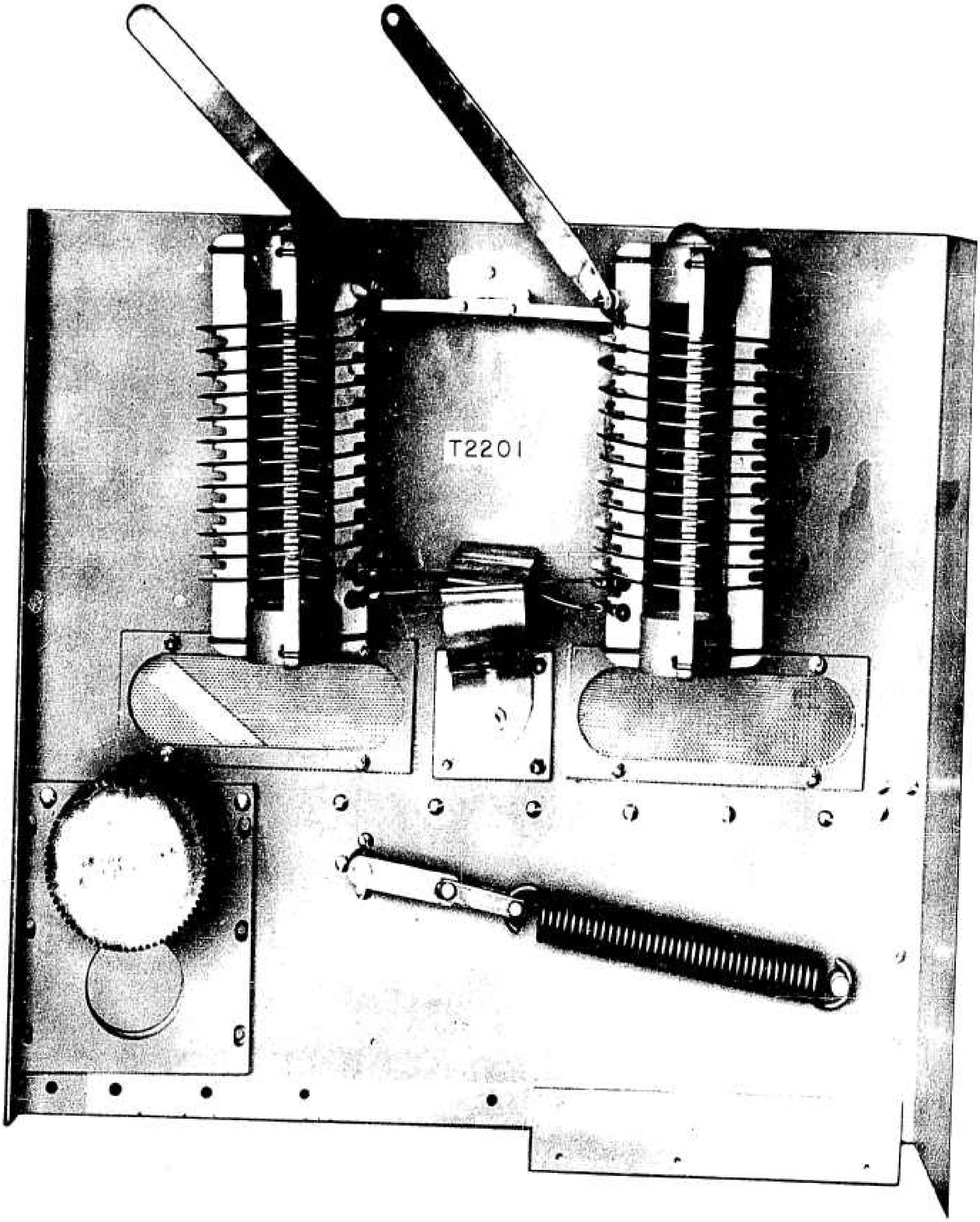


Figure 133. 40-Kw RF Amplifier Input Circuit.

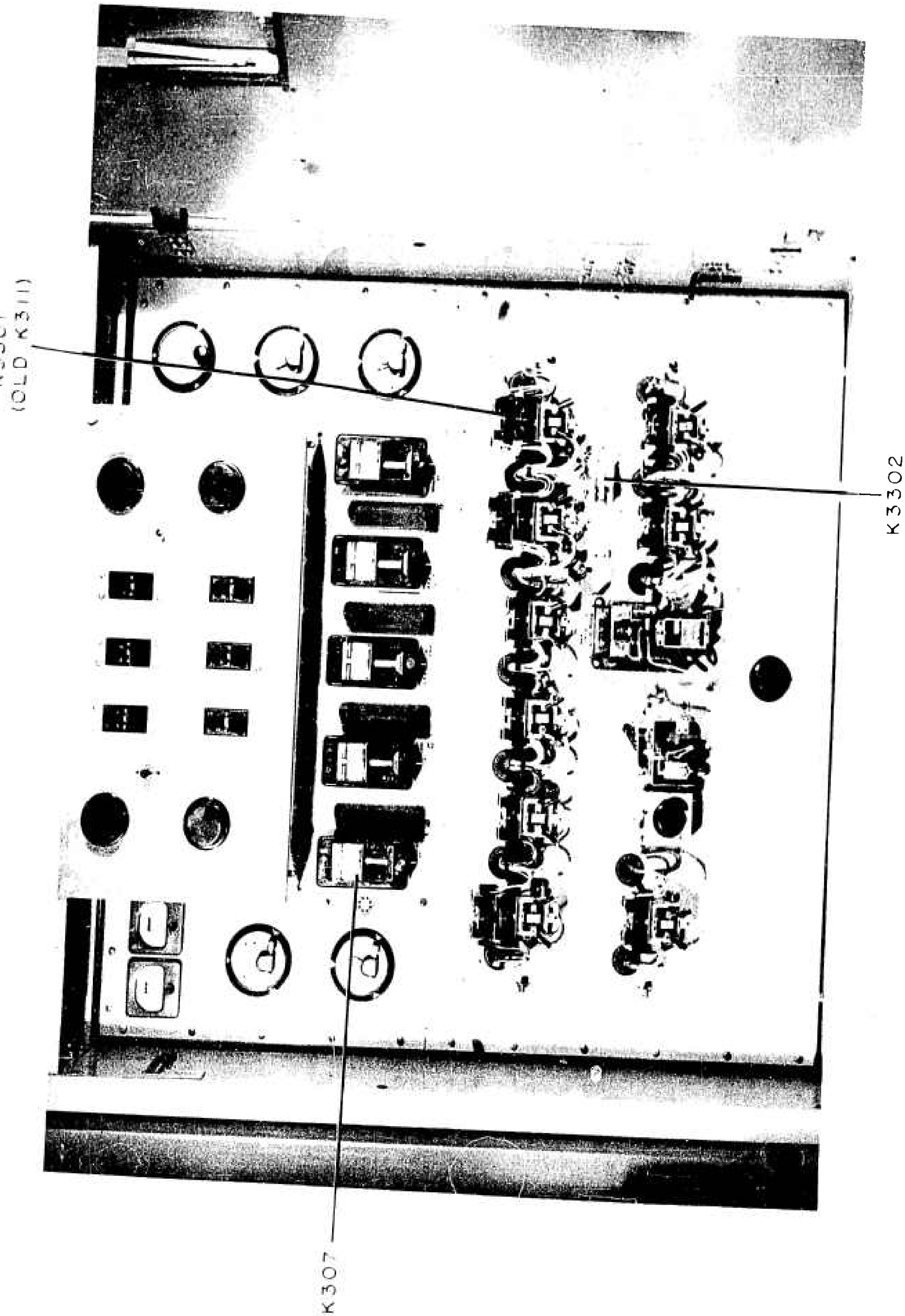


Figure 134. Power Supply Assembly PP-1088/FRT-26 Relay Panel.

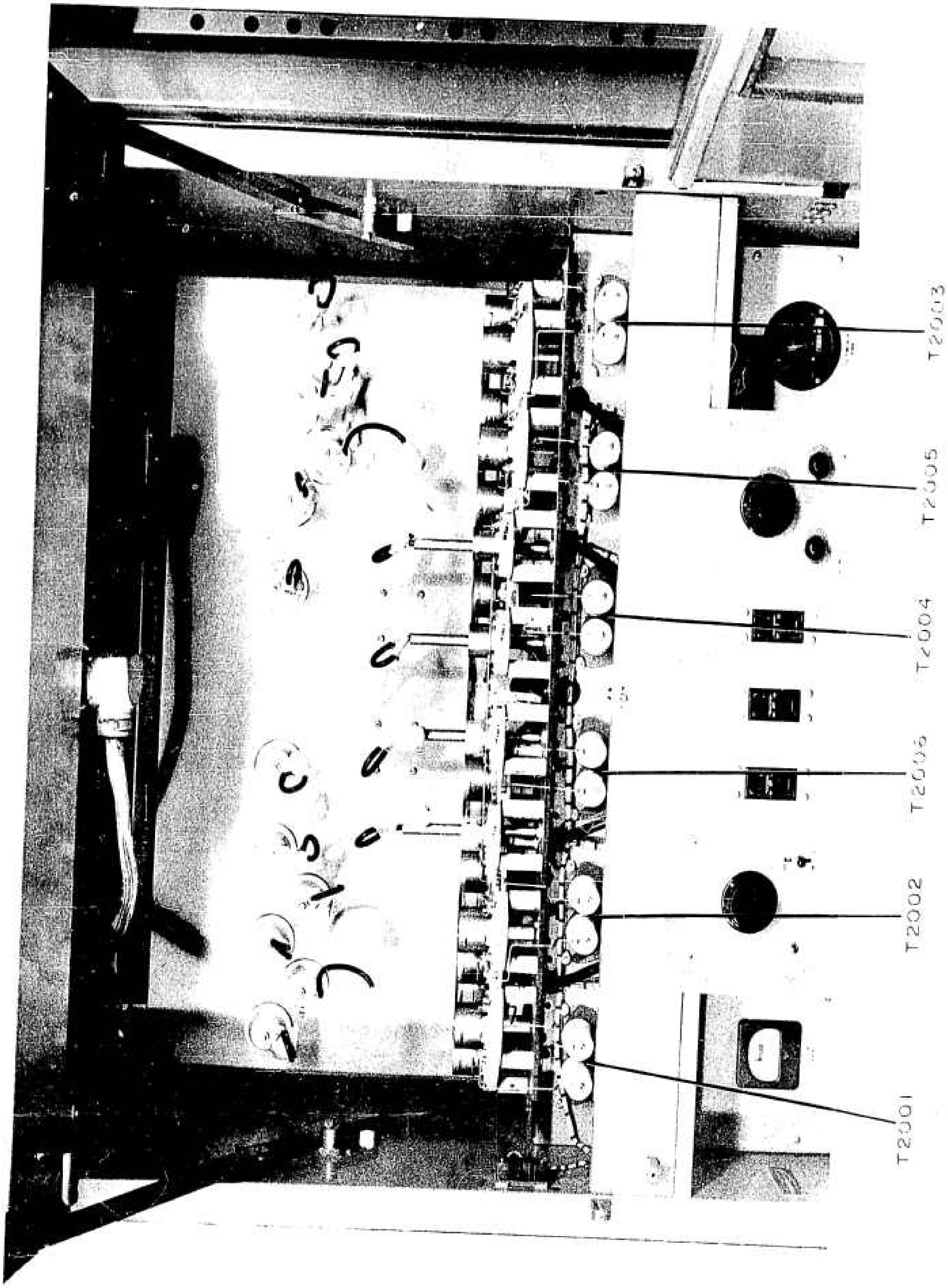


Figure 135.10-Kv Rectifier Upper Compartment, Door Open and Cover Removed.

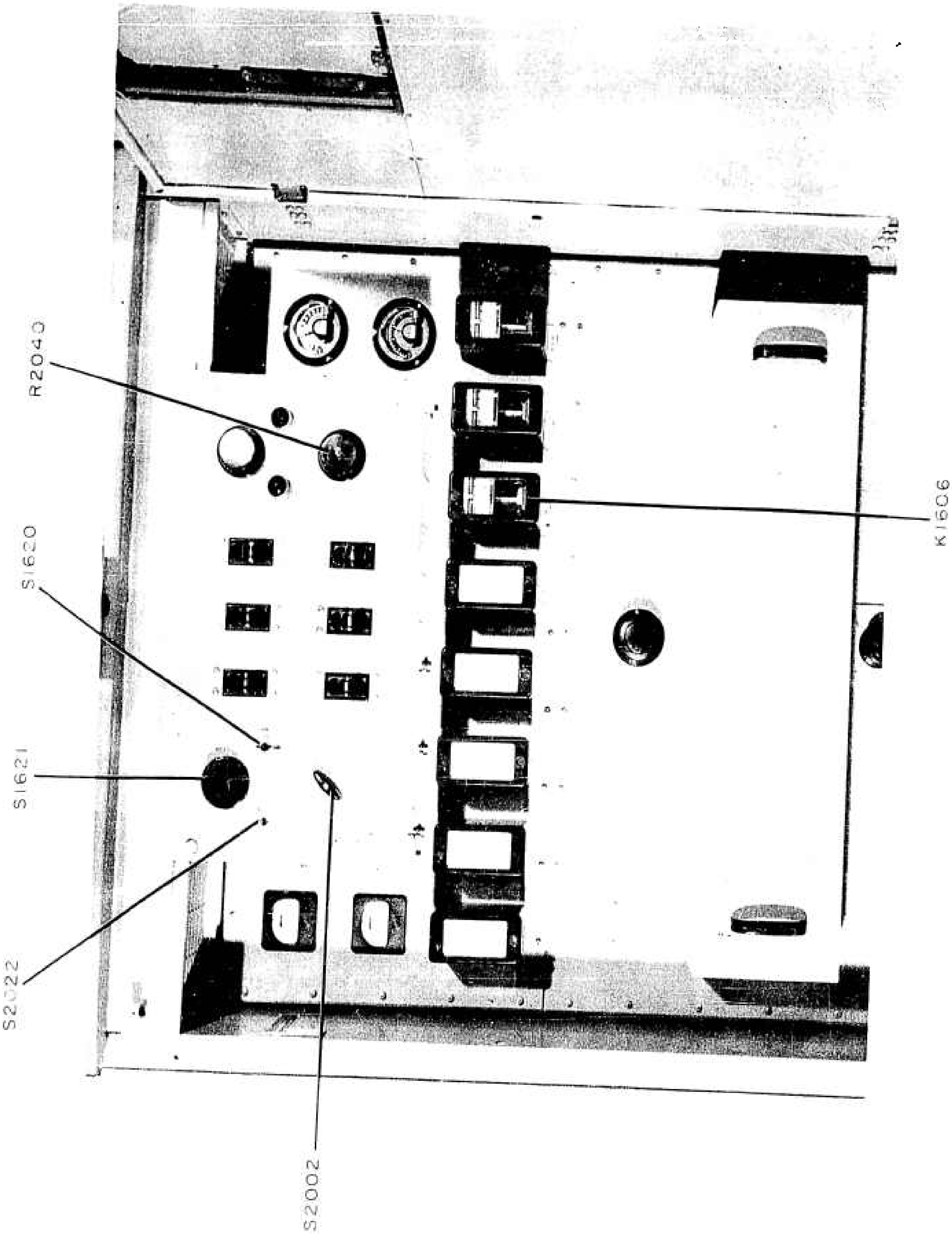


Figure 136. 10-Kv Rectifier Lower Front Panel, Door Open.

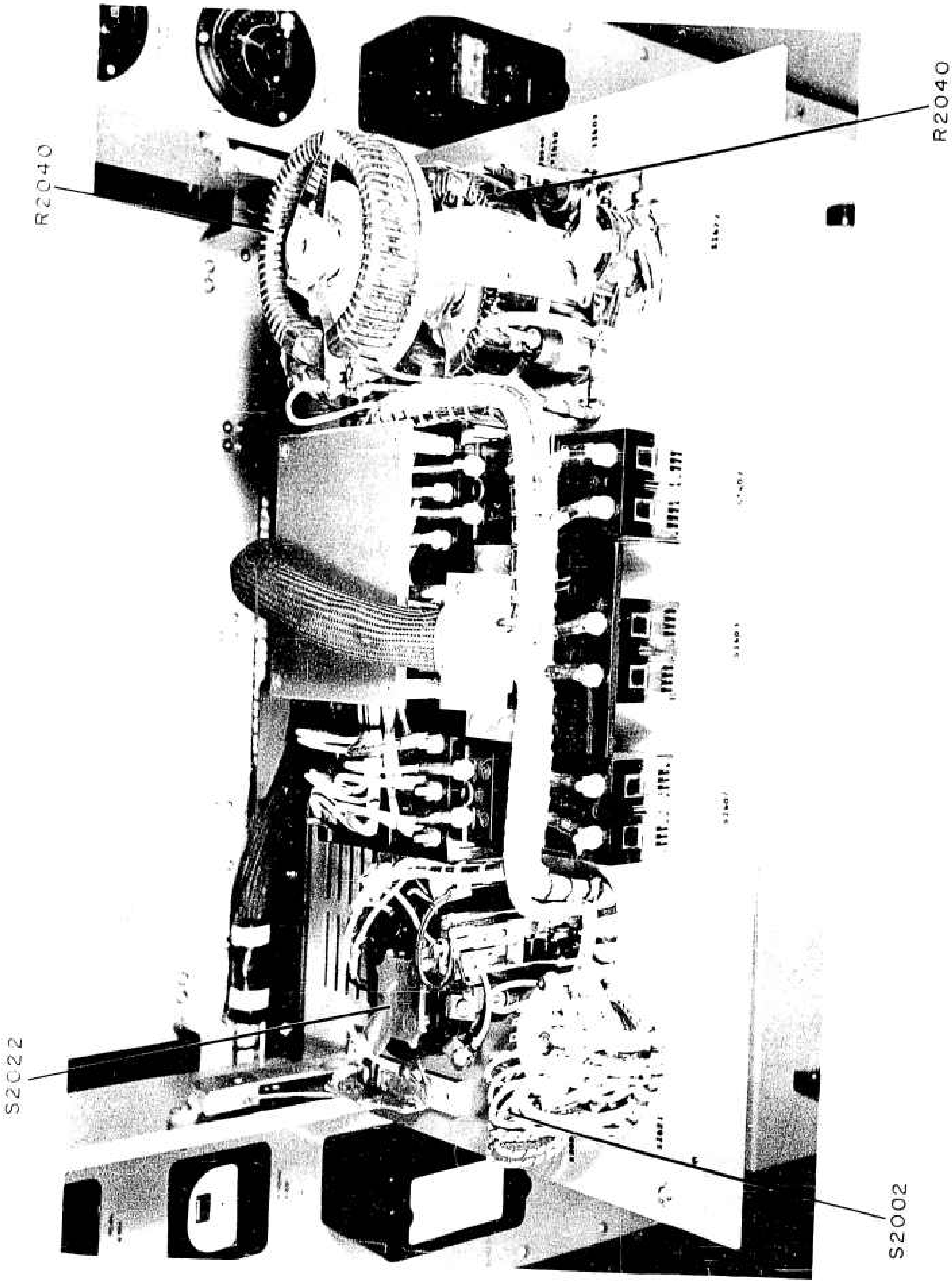


Figure 137. 10-Kv Rectifier, Rear of Lower Control Panel.

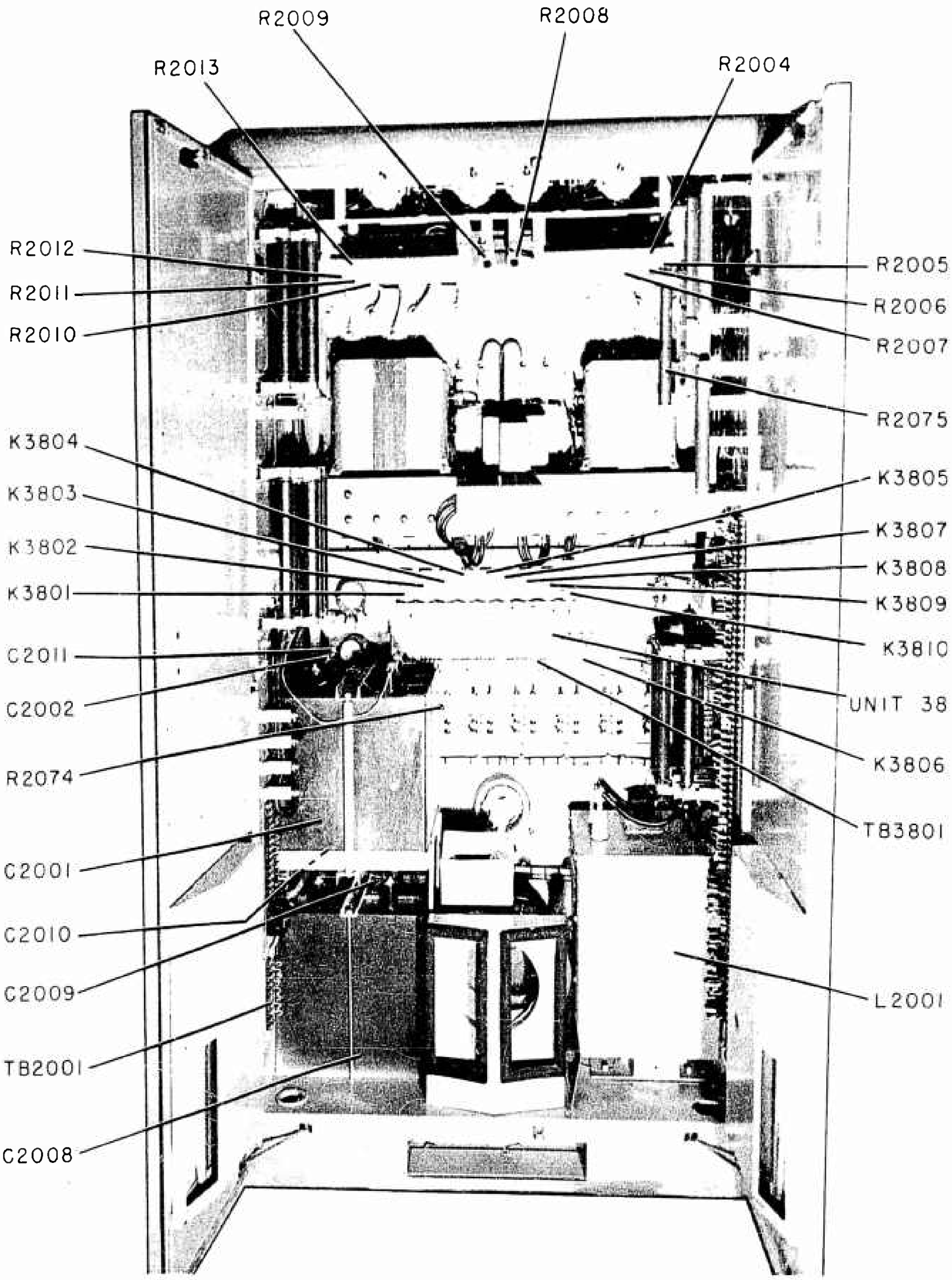


Figure 138. 10-Kv Rectifier, Rear View, Doors Open.

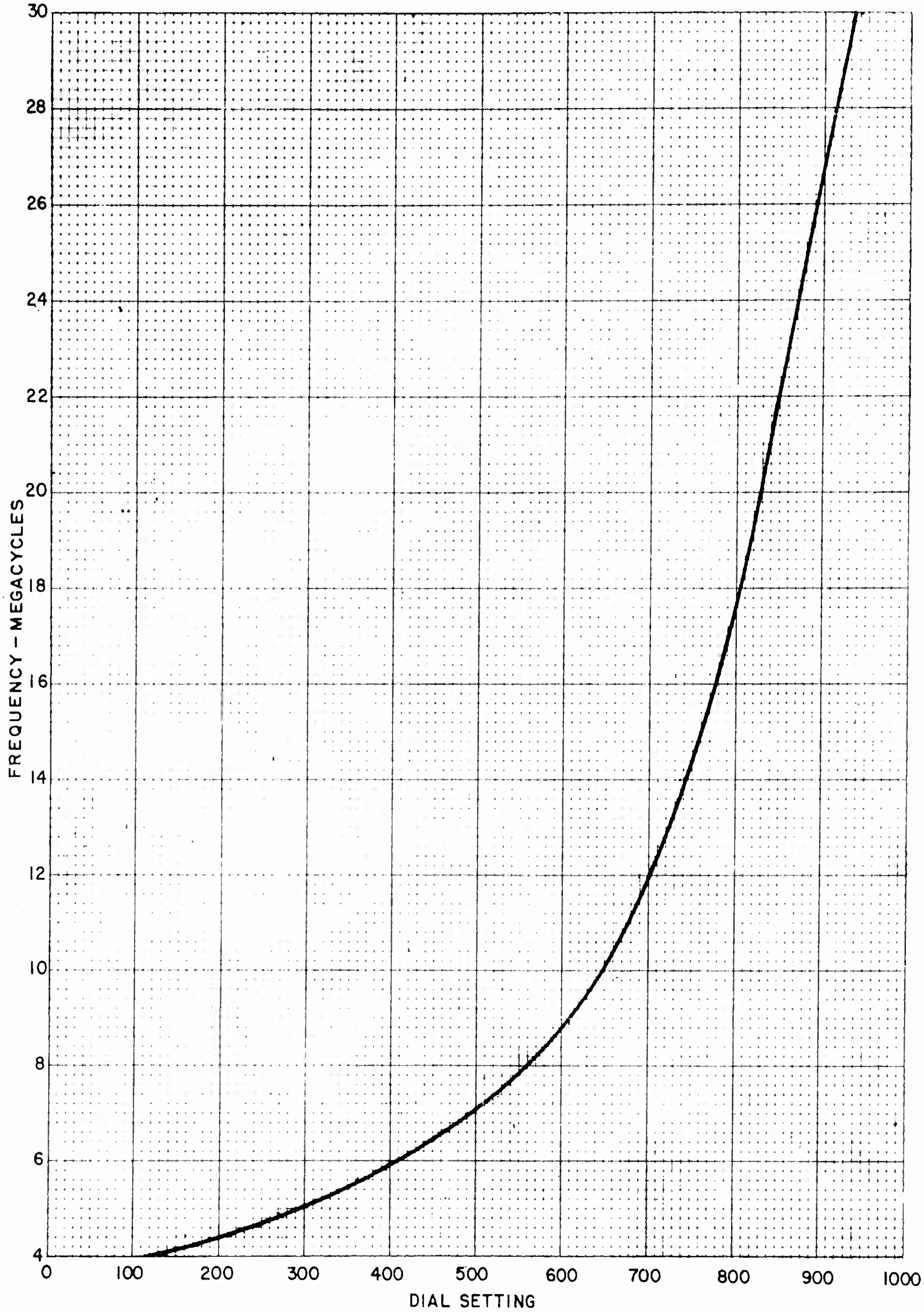


Figure 139. Tuning Chart. DRIVER PLATE Servo Control.

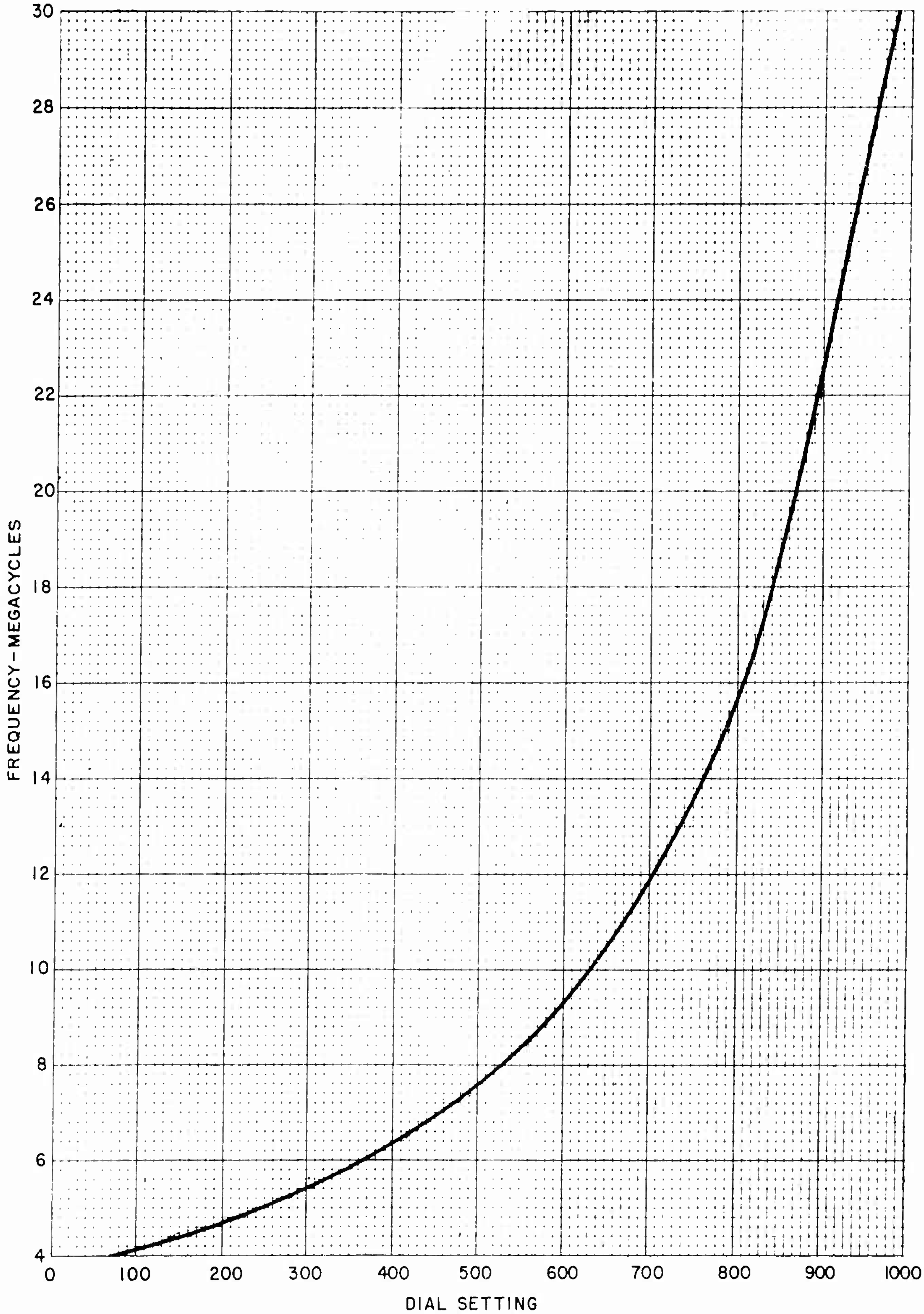


Figure 140. Tuning Chart, POWER AMPLIFIER PLATE TUNING Servo Control.

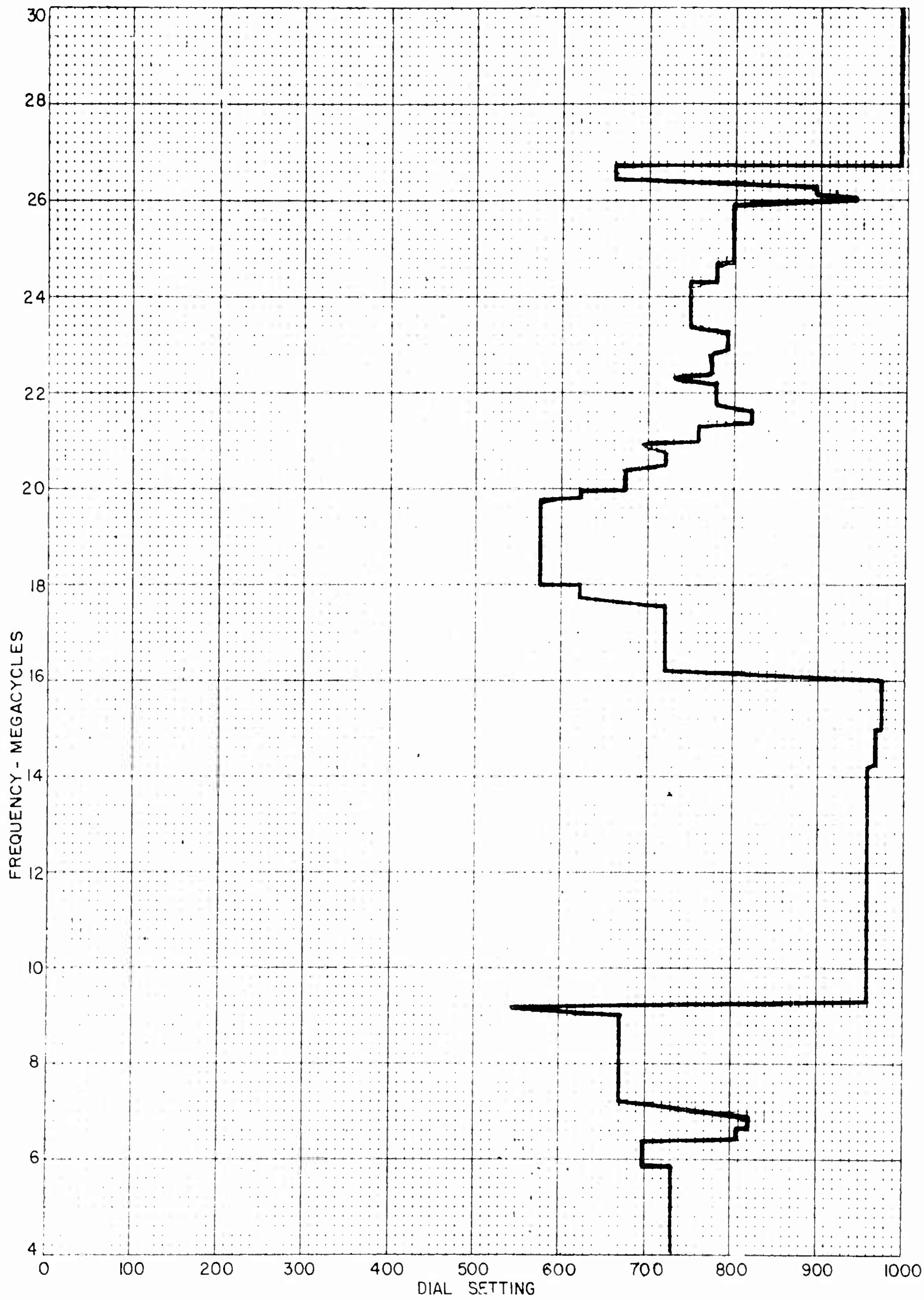


Figure 141. Tuning Chart. POWER AMPLIFIER LOADING Servo Control.

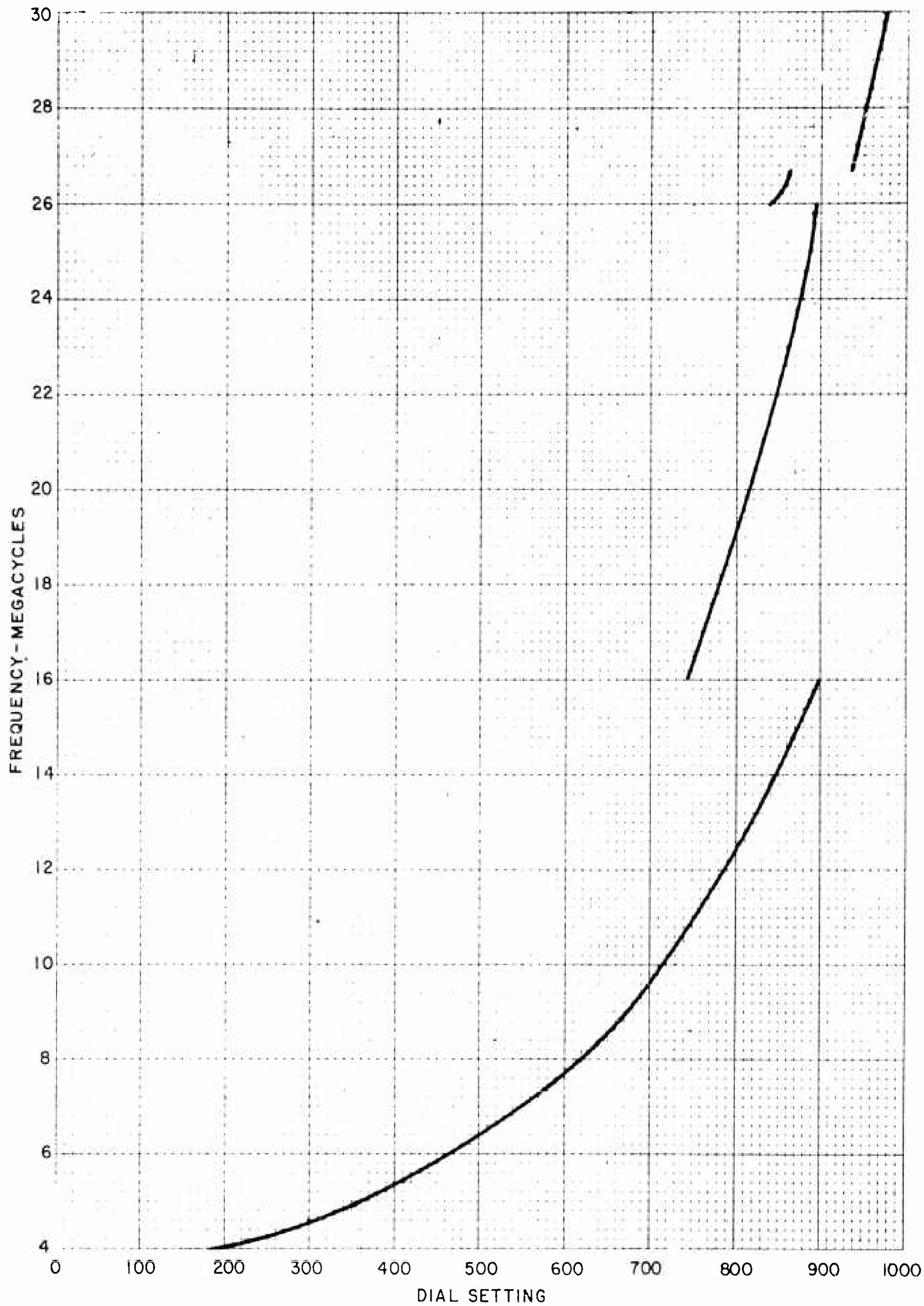


Figure 142. Tuning Chart, ANTENNA TUNING Servo Control.

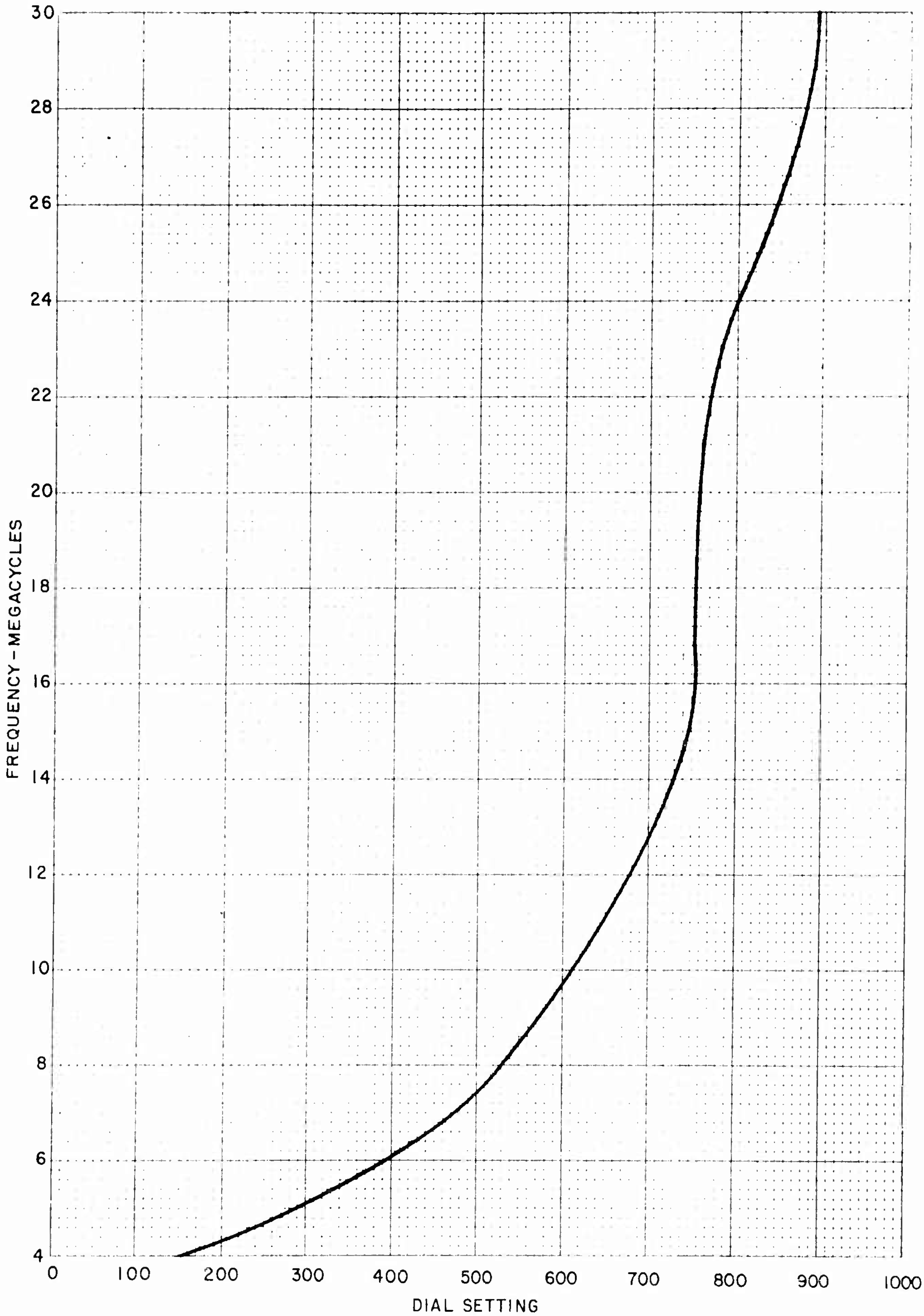


Figure 143. Tuning Chart, 40-Kw GRID TUNING Servo Control.

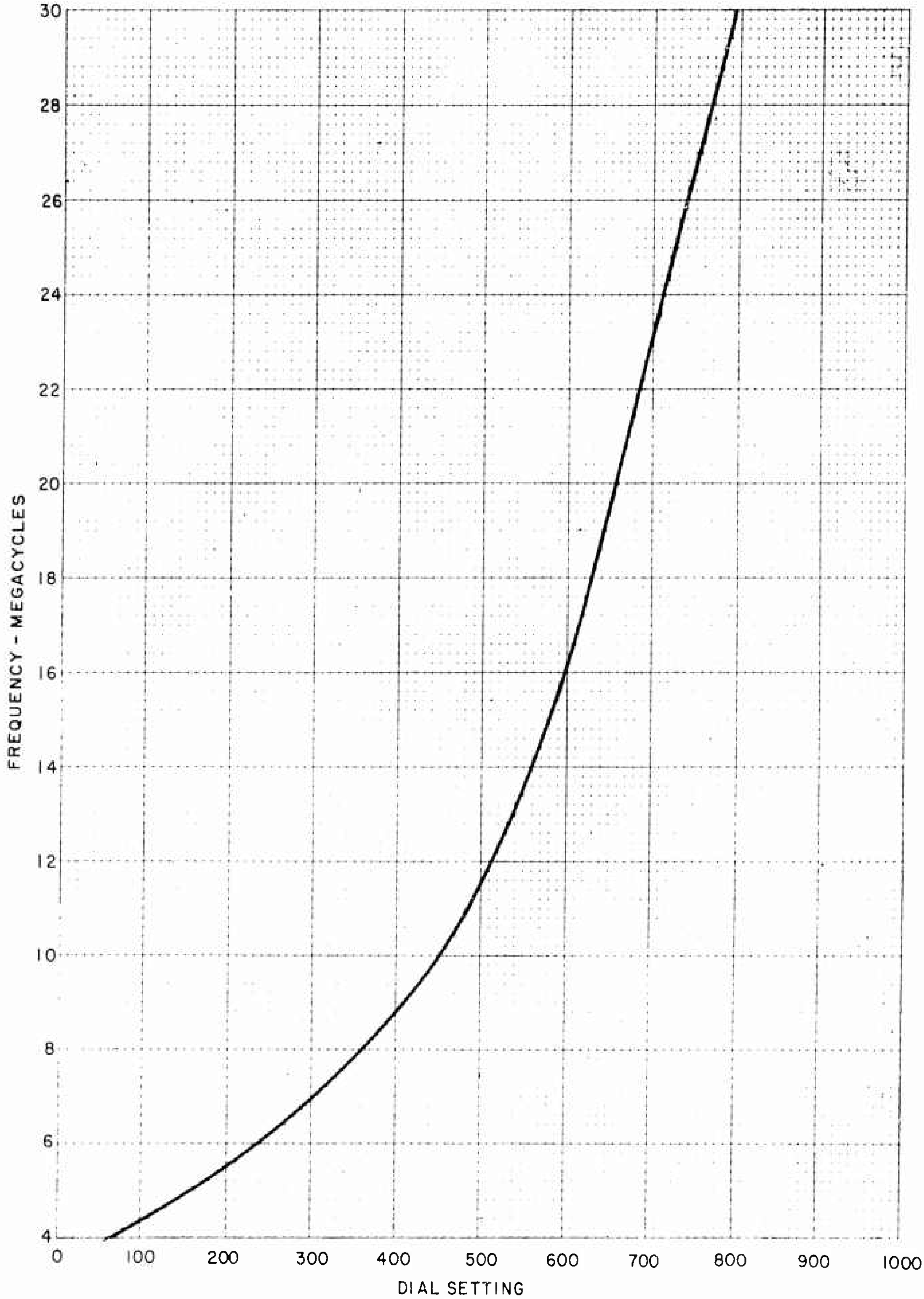


Figure 144. Tuning Chart, 40-Kw PLATE TUNING Servo Control.

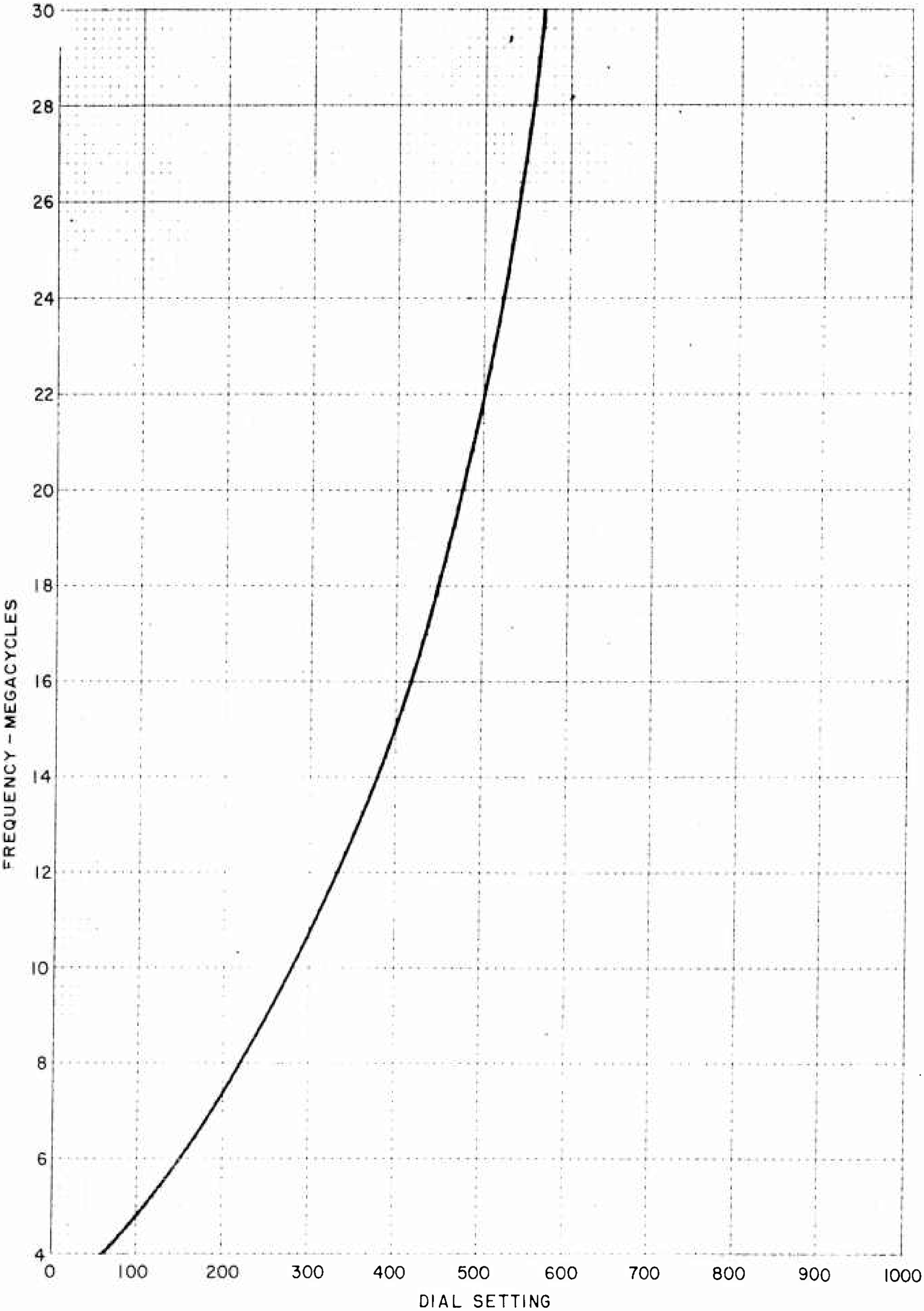
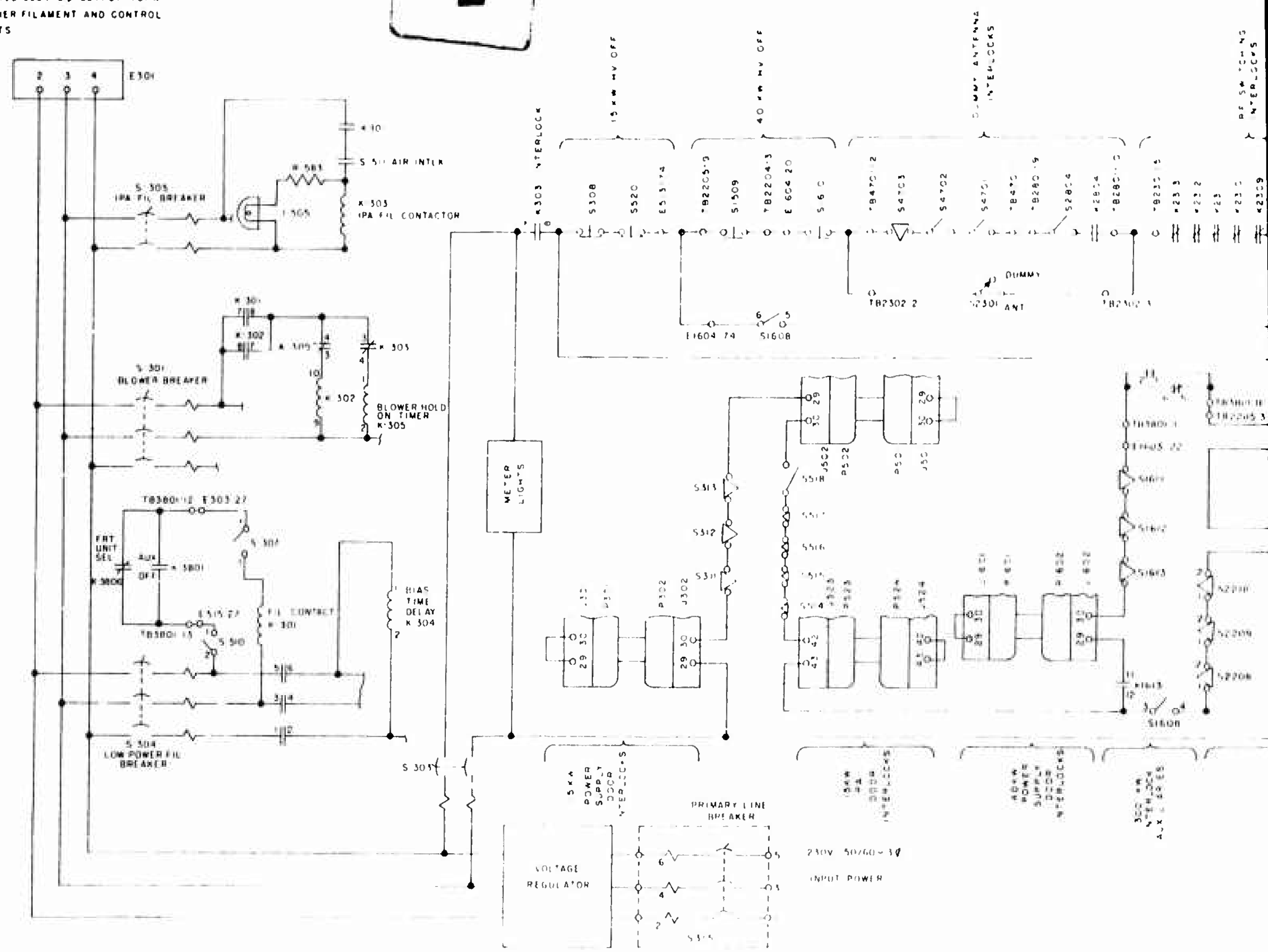


Figure 145. Tuning Chart, 40-Kw PLATE LOADING Servo Control.

1

REGULATED 230V 3Ø OUTPUT 40KW AMPLIFIER FILAMENT AND CONTROL CIRCUITS



2

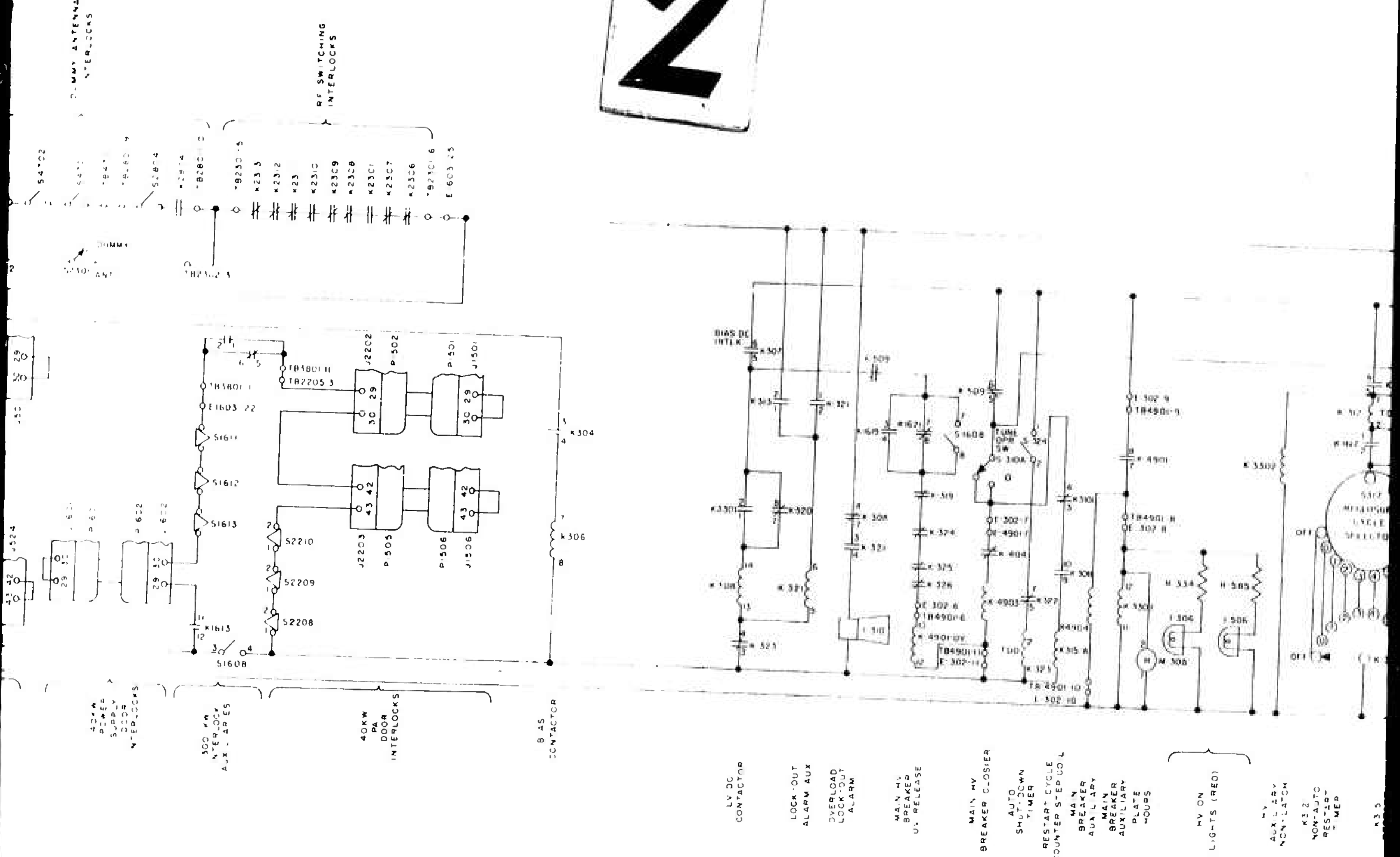


Figure 146 . Ladder Diagram

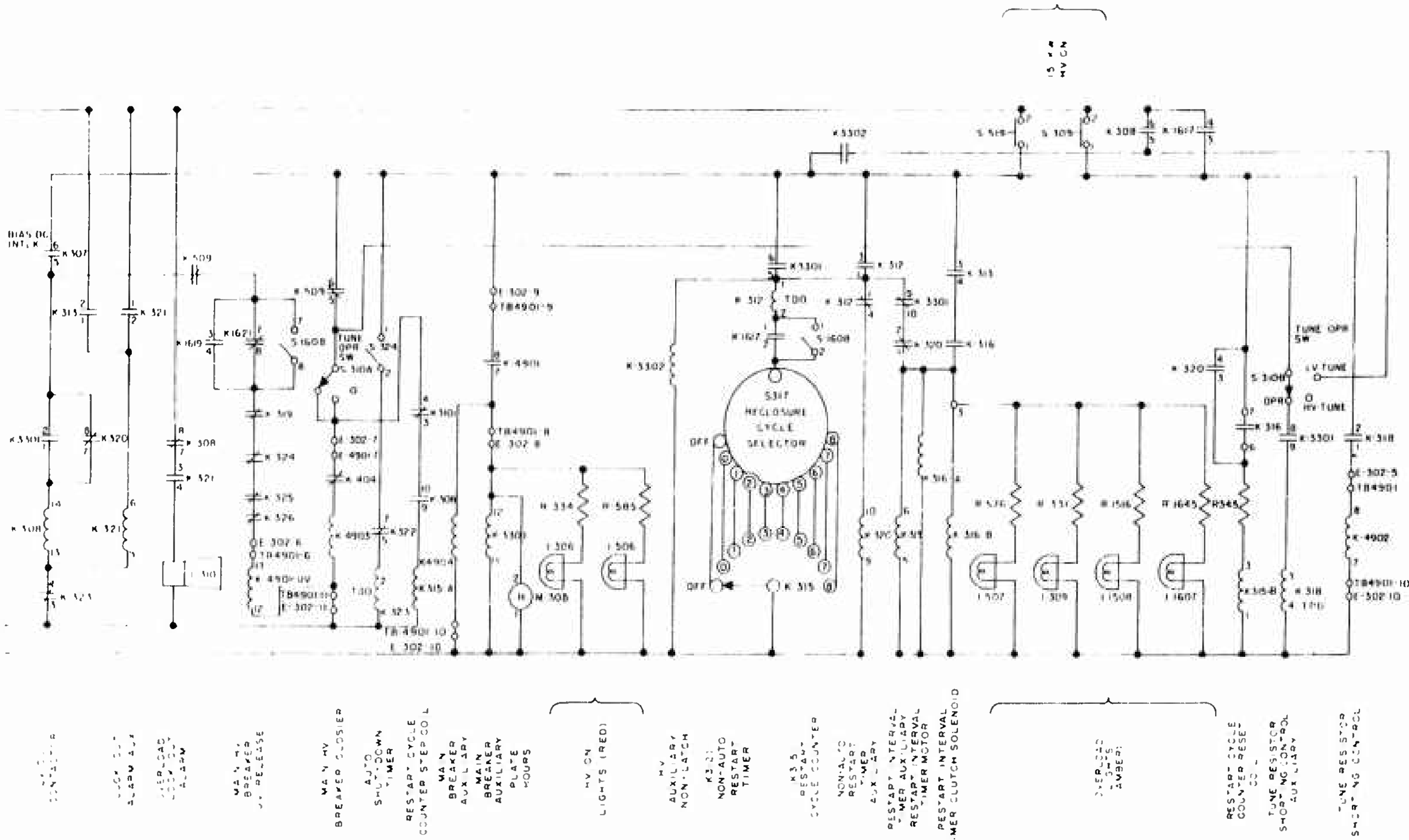
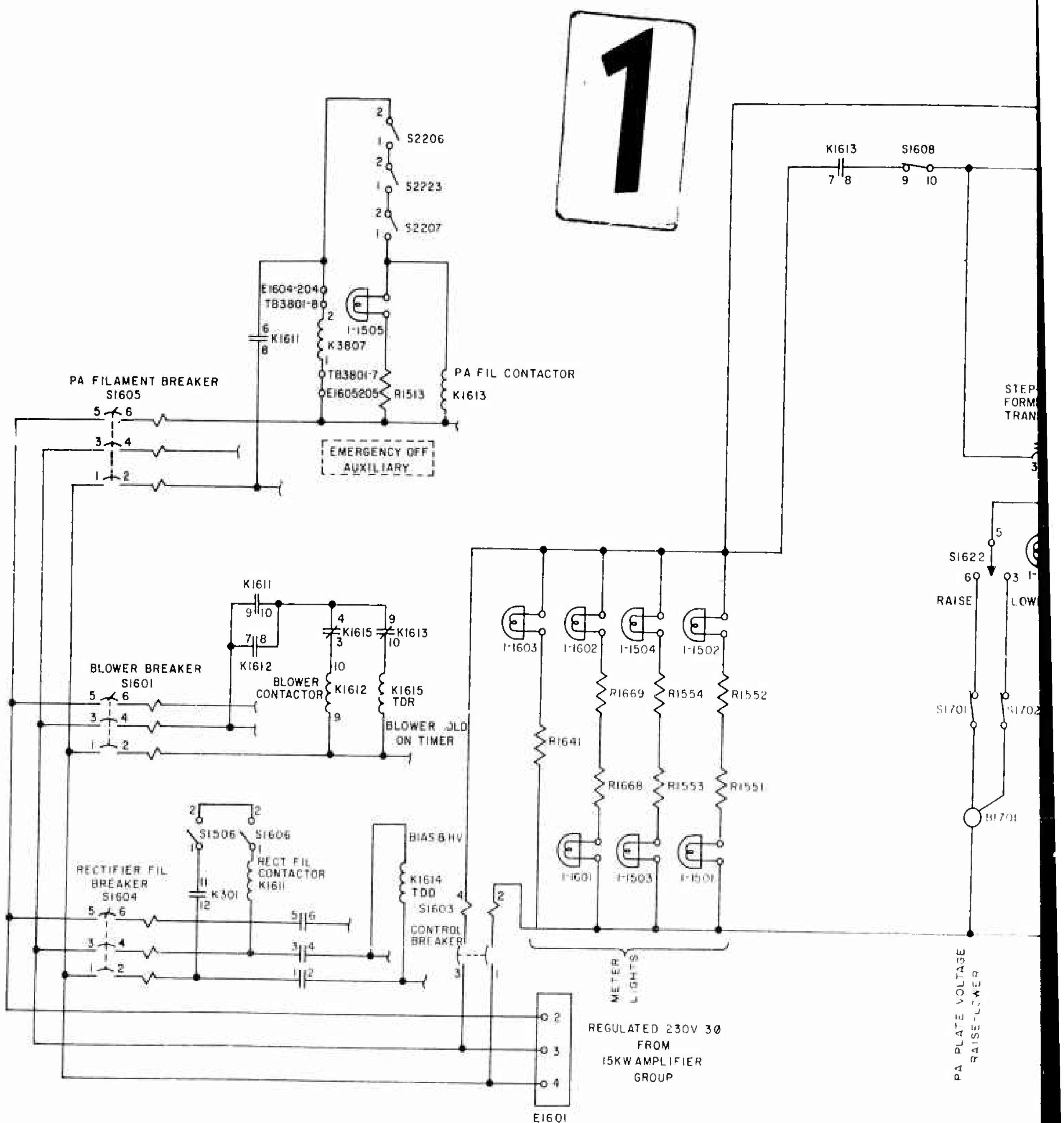


Figure 146 . Ladder Diagram, IPA Power Control Circuit.


1
S2206
S2223
S2207
E1604-204
TB3801-8
K1611
K3807
I-1505
TB3801-7
E1605205
R1513
PA FIL CONTACTOR
K1613
PA FILAMENT BREAKER
S1605
EMERGENCY OFF
AUXILIARY
K1613
S1608
STEP-
FORM
TRAN
S1622
RAISE
LOW
K1611
K1612
K1615
K1613
BLOWER BREAKER
S1601
BLOWER
CONTACTOR
K1612
K1615
TDR
BLOWER OLD
ON TIMER
I-1603
I-1602
I-1504
I-1502
R1669
R1554
R1552
R1641
R1668
R1553
R1551
S1701
S1702
B1701
S1506
S1606
RECT FIL
CONTACTOR
K1611
BIAS & HV
RECTIFIER FIL
BREAKER
S1604
K301
K1614
TDO
S1603
CONTROL
BREAKER
I-1601
I-1503
I-1501
METER
LIGHTS
PA PLATE VOLTAGE
RAISE-LOWER
REGULATED 230V 3Ø
FROM
15KW AMPLIFIER
GROUP
E1601

2

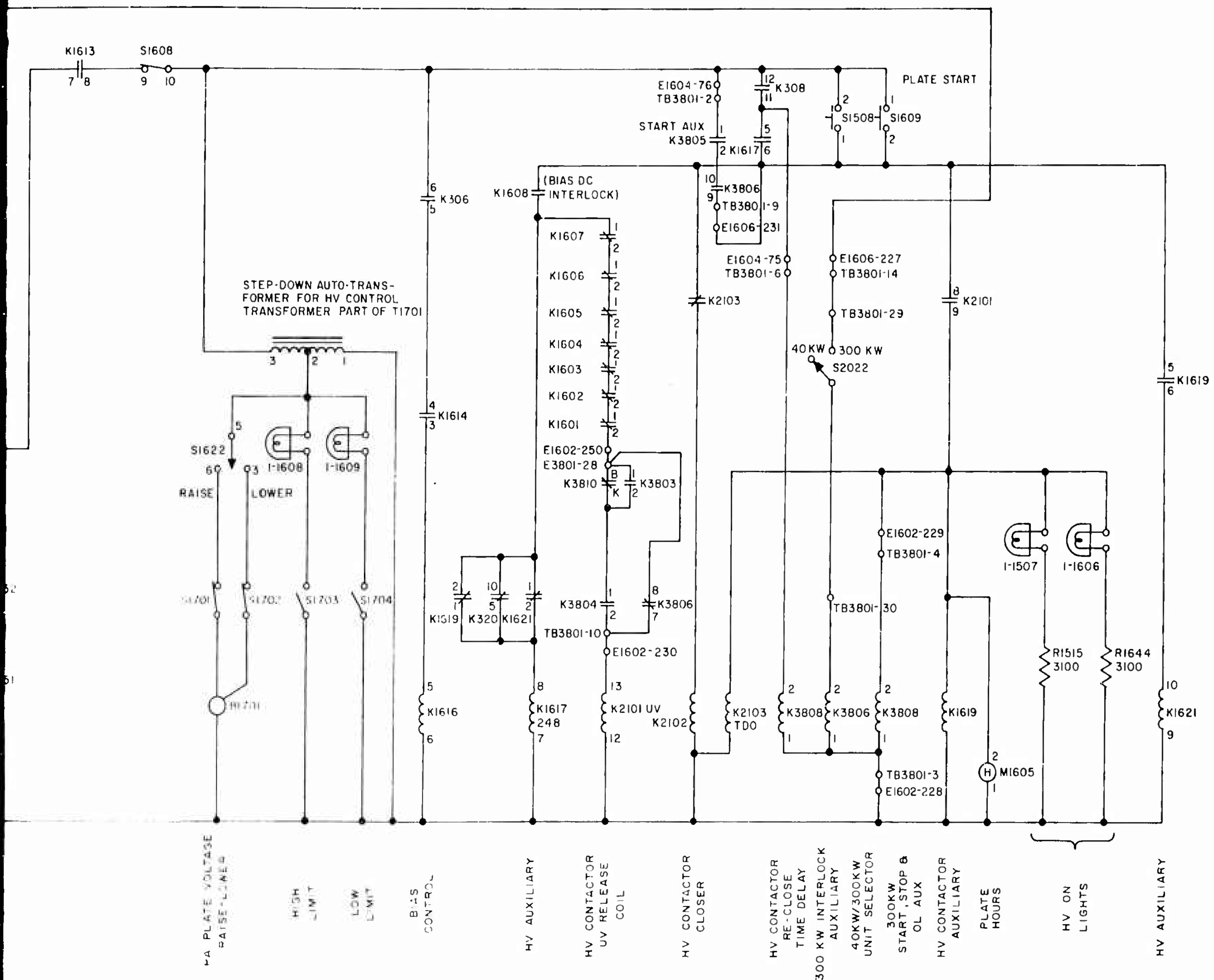


Figure 147. Ladder Diagram, 40-Kw Power Control Circuit.

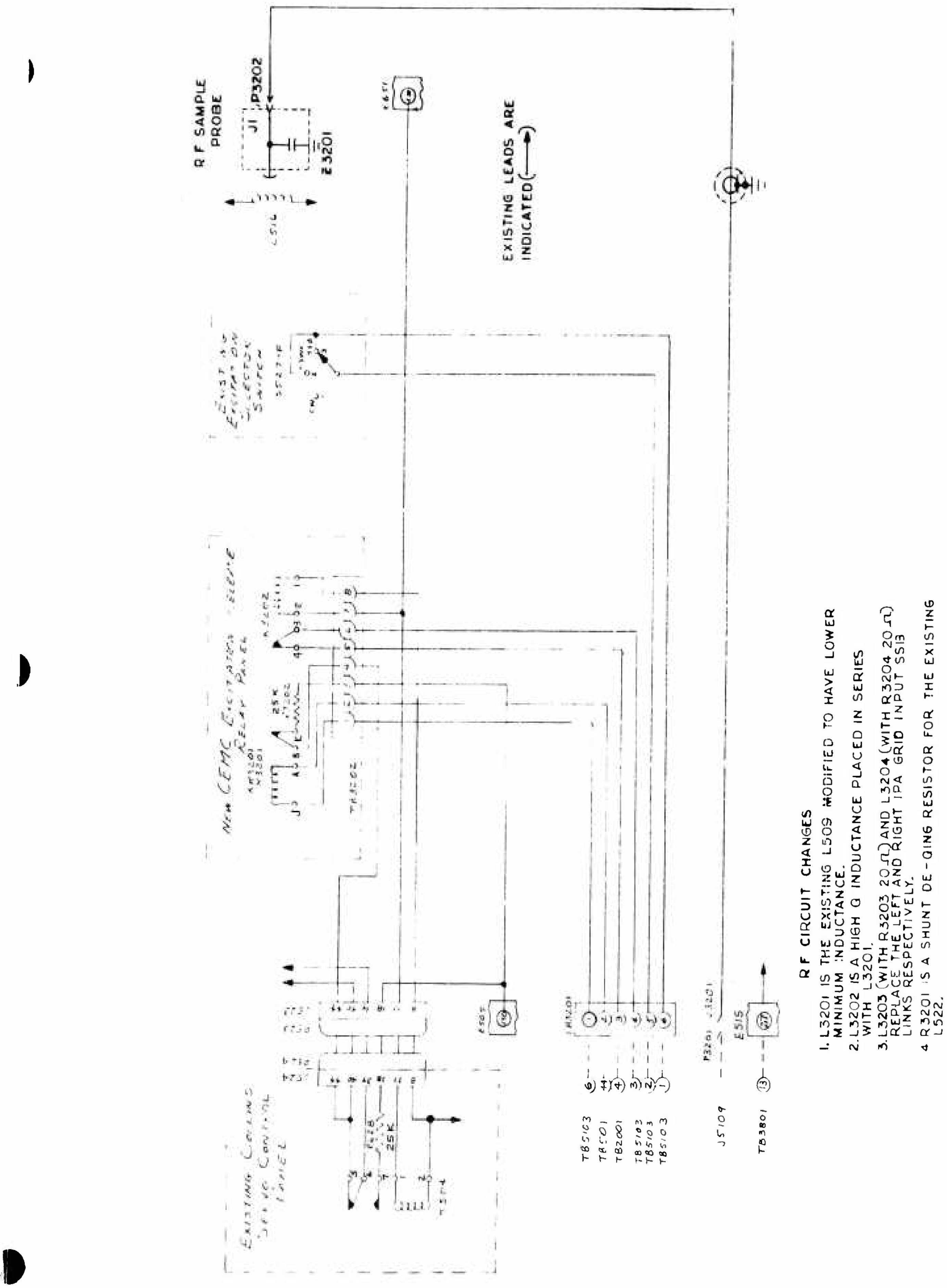


Figure 148. Schematic Diagram, Modifications to Radio Transmitter T-454/FRT-26.

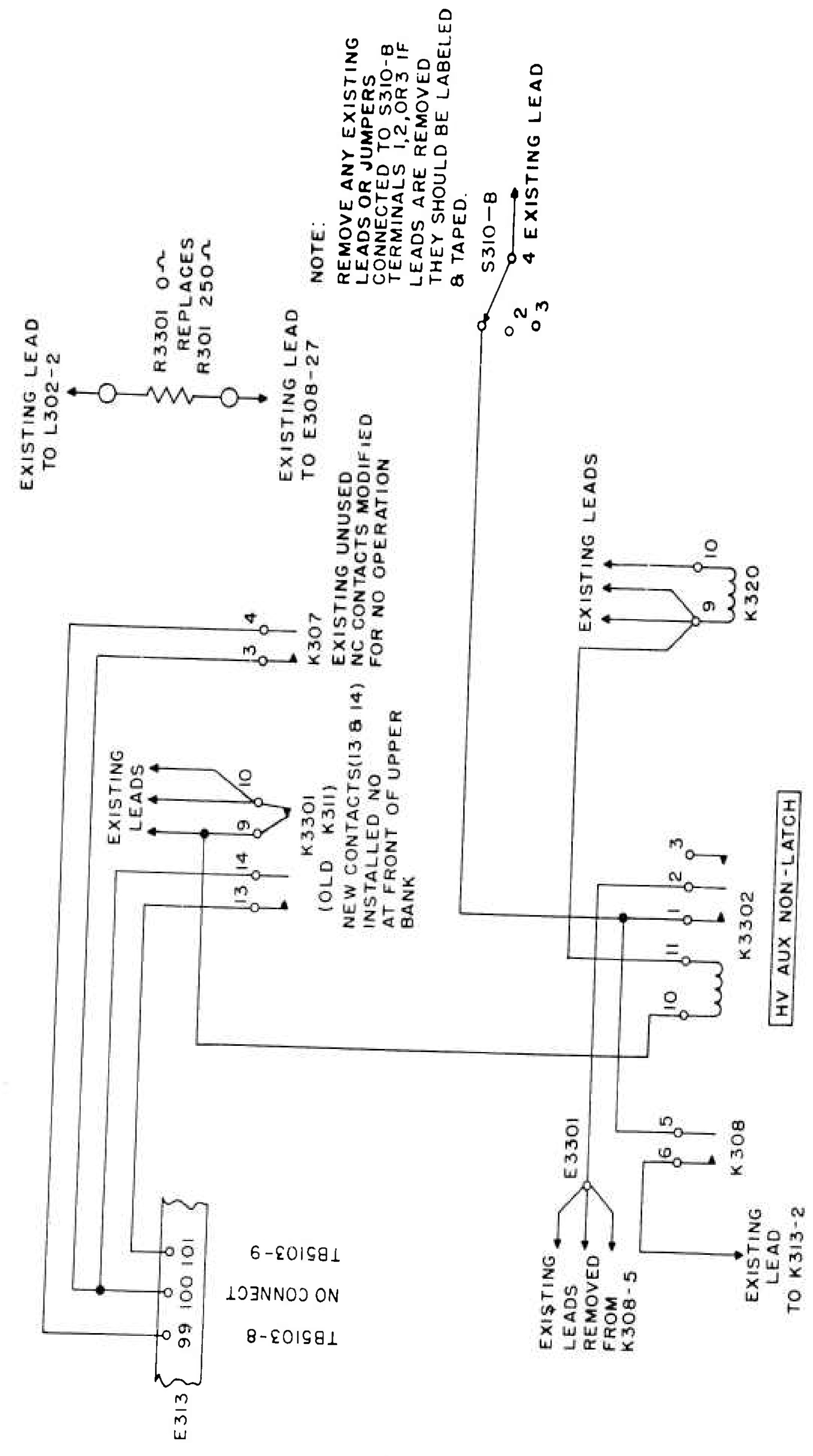


Figure 149. Schematic Diagram, Modifications to Power Supply Assembly PP-1088/FRT-26.

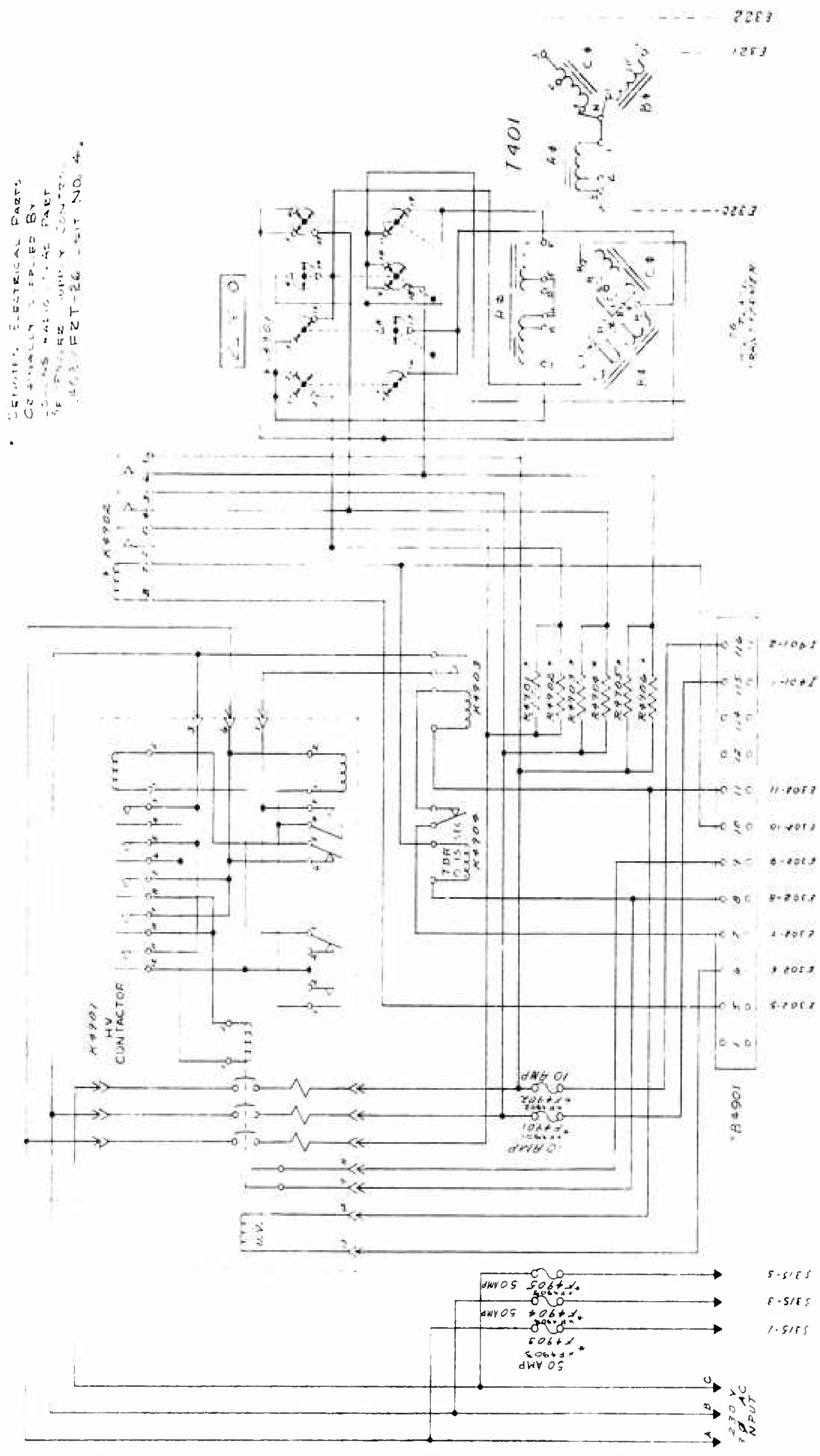
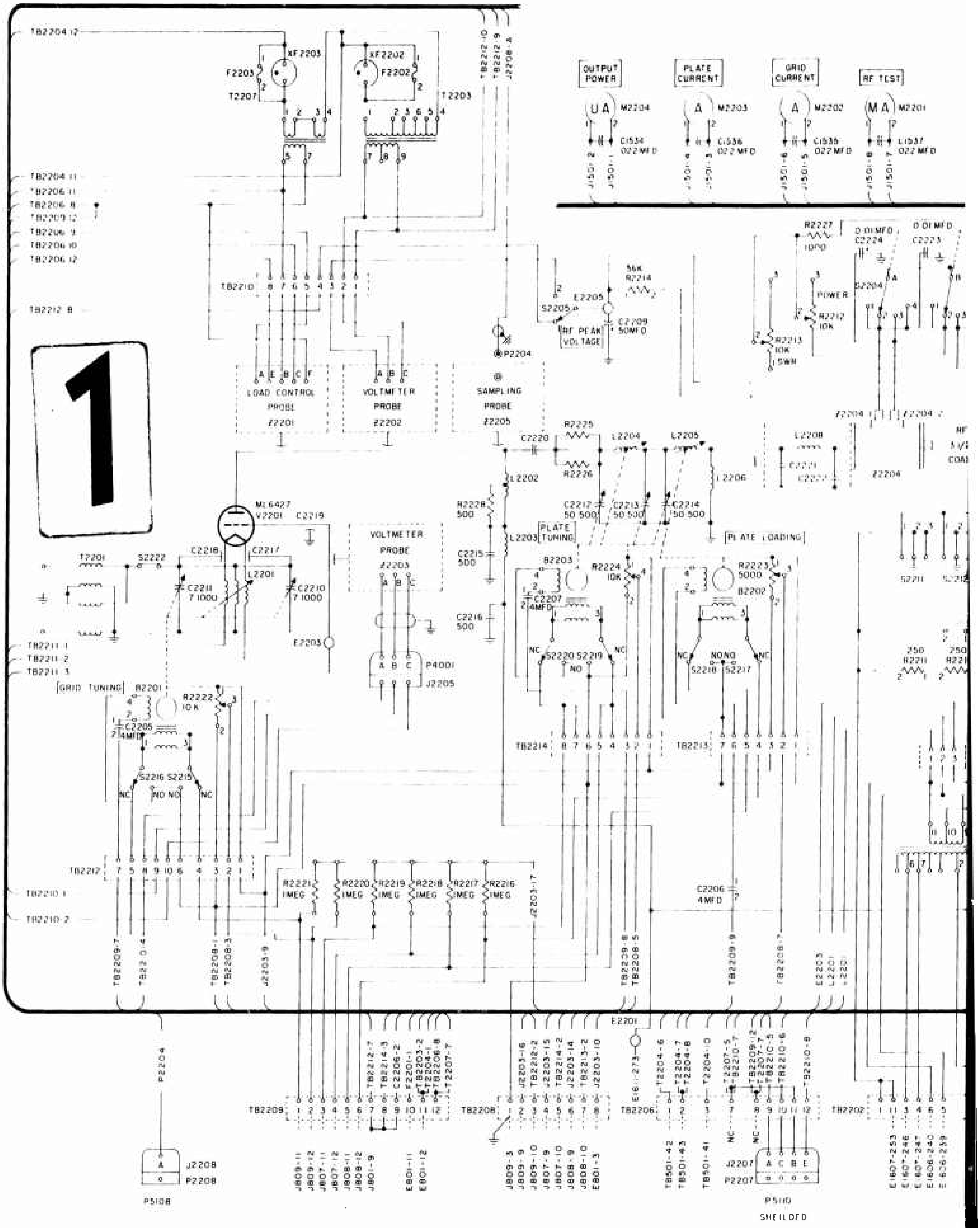


Figure 150. Schematic Diagram, IPA Power Control, as Modified.


1
OUTPUT POWER
PLATE CURRENT
GRID CURRENT
RF TEST
M2204
M2203
M2202
M2201
XF2203
XF2202
F2203
F2202
T2207
T2203
TB2210
LOAD CONTROL PROBE Z2201
VOLTMETER PROBE Z2202
SAMPLING PROBE Z2205
RF PEAK VOLTAGE
POWER
ML6427 V2201
VOLTMETER PROBE Z2203
PLATE TUNING
PLATE LOADING
GRID TUNING
TB2214
TB2213
TB2212
TB2209
TB2208
TB2206
TB2202
P4001
J2205
J2208
P2208
P5108
J2207
P2207
P5110
SHEILDED

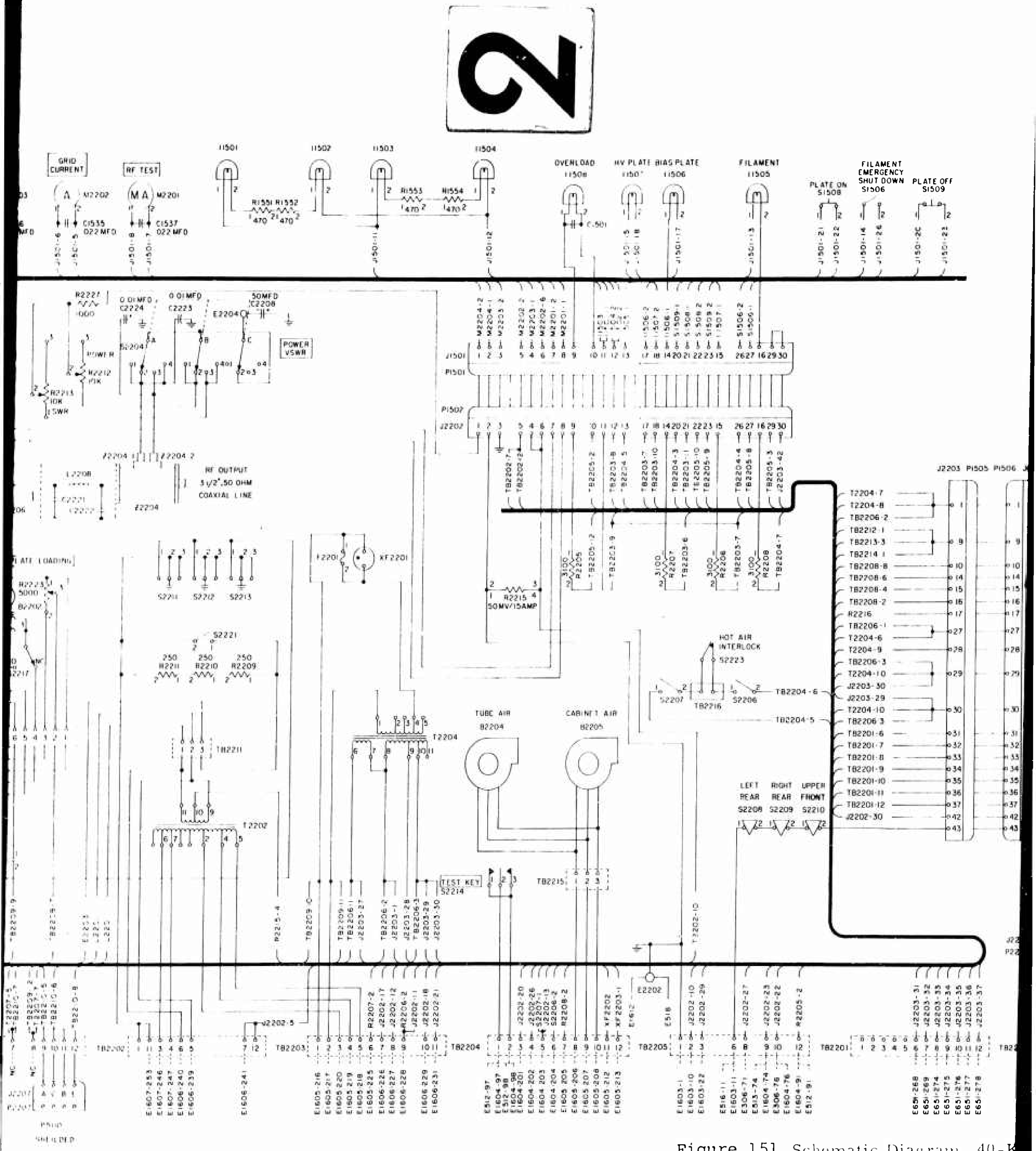


Figure 151. Schematic Diagram, 40-K

3

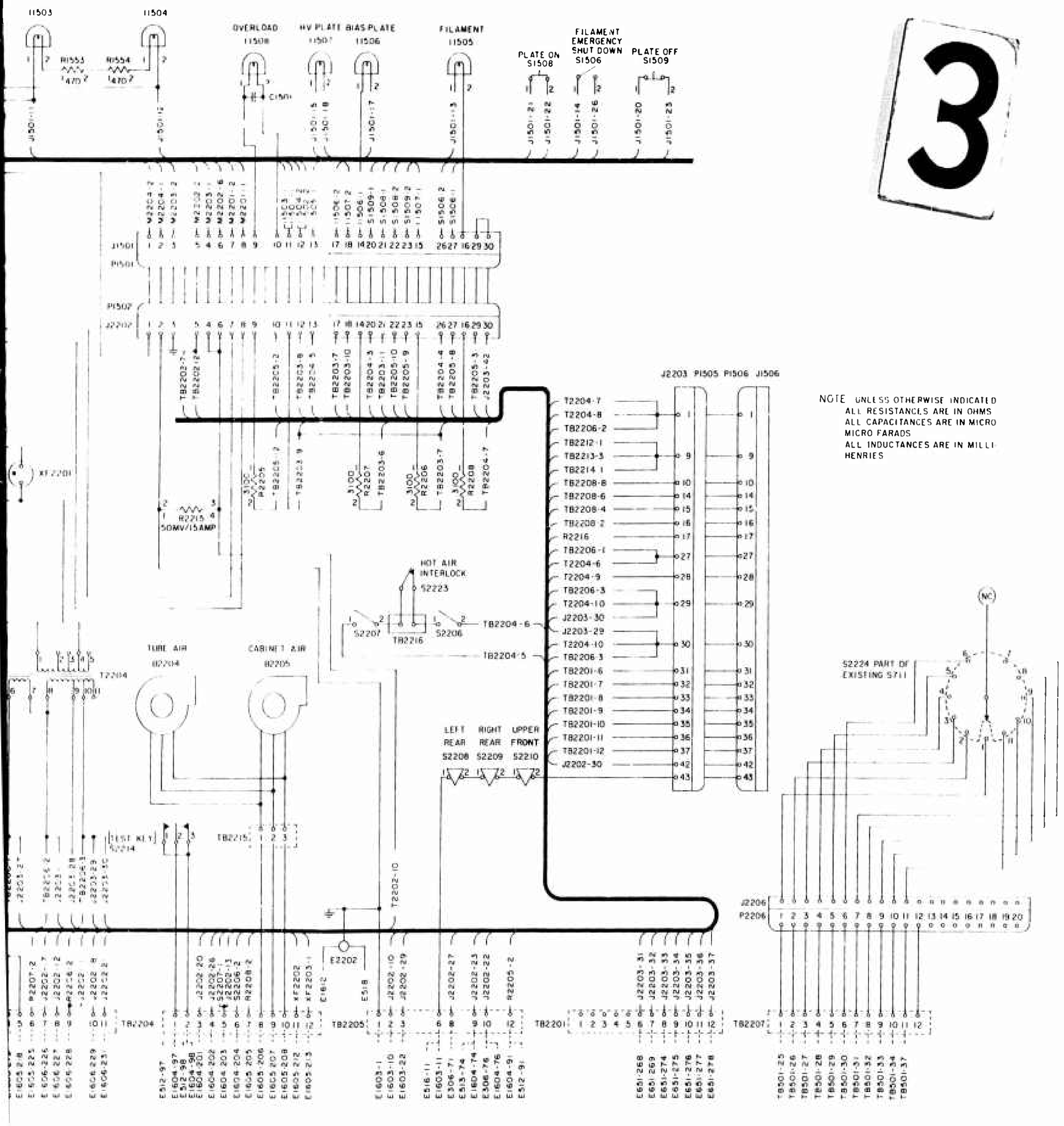


Figure 151. Schematic Diagram, 40-Kw RF Amplifier.

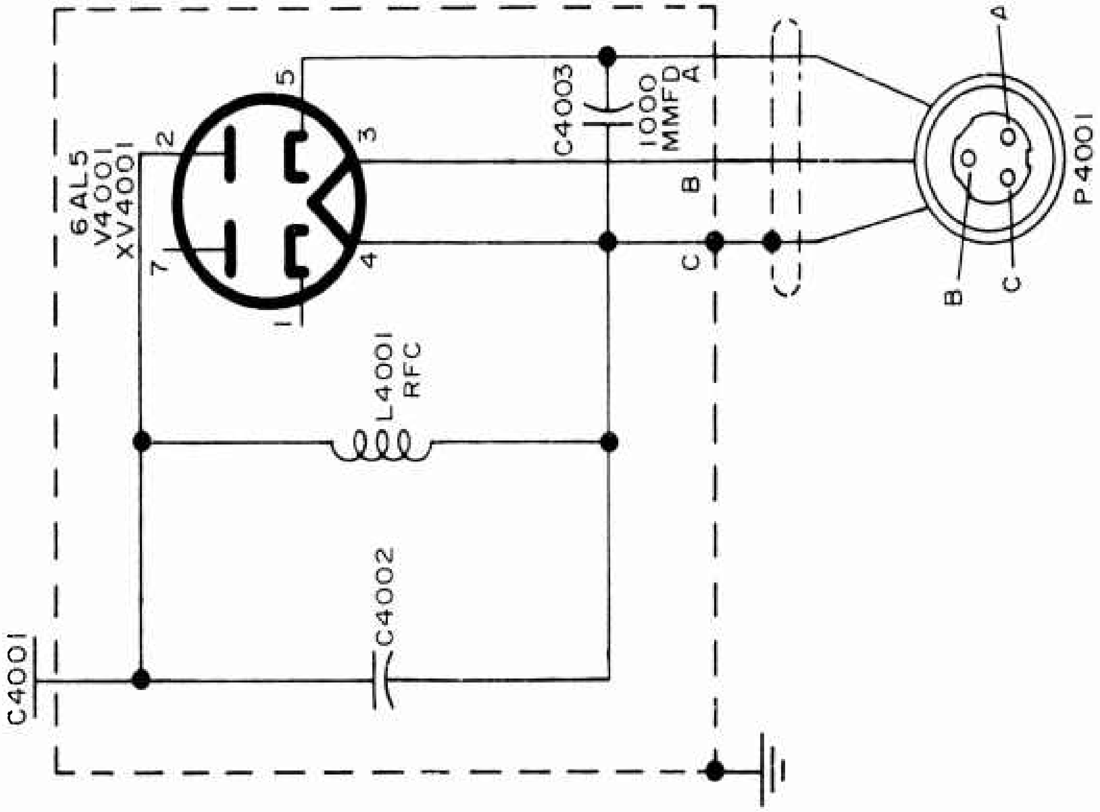


Figure 152. Schematic Diagram, Vacuum-Tube Voltmeter Probes Z2202 and Z2203.

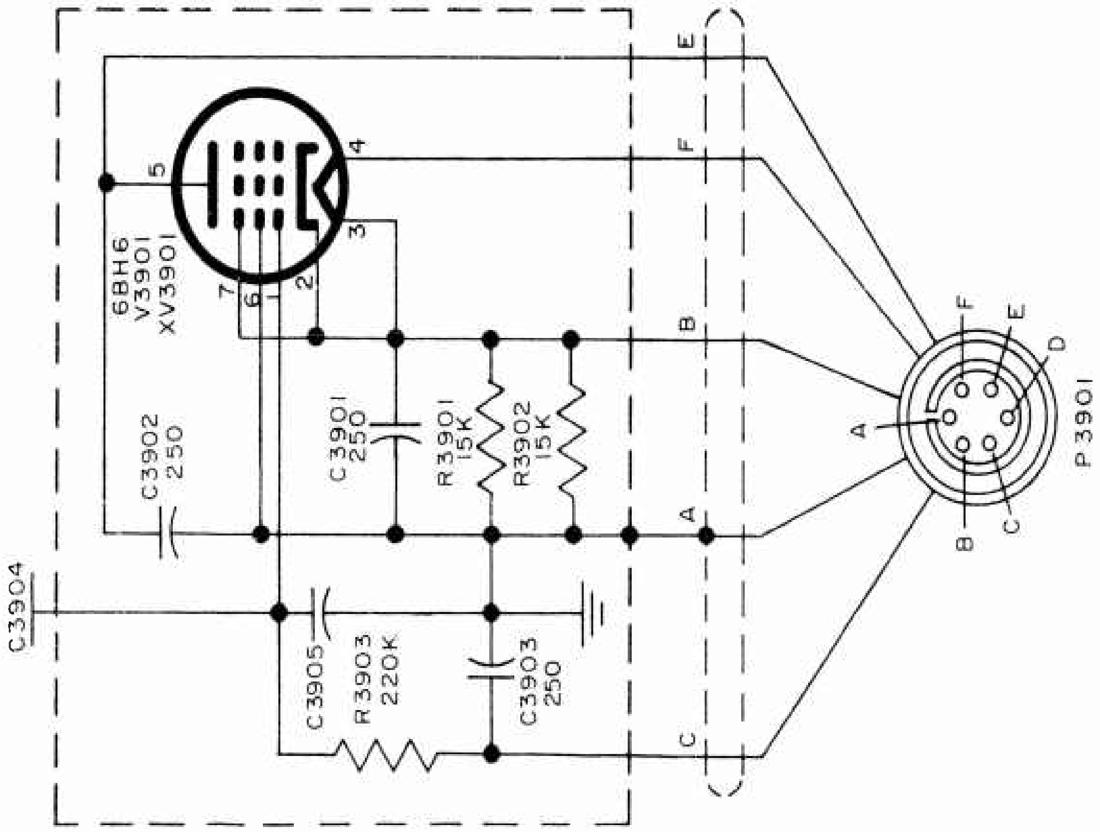


Figure 153. Schematic Diagram, ALC Probe Z2201.

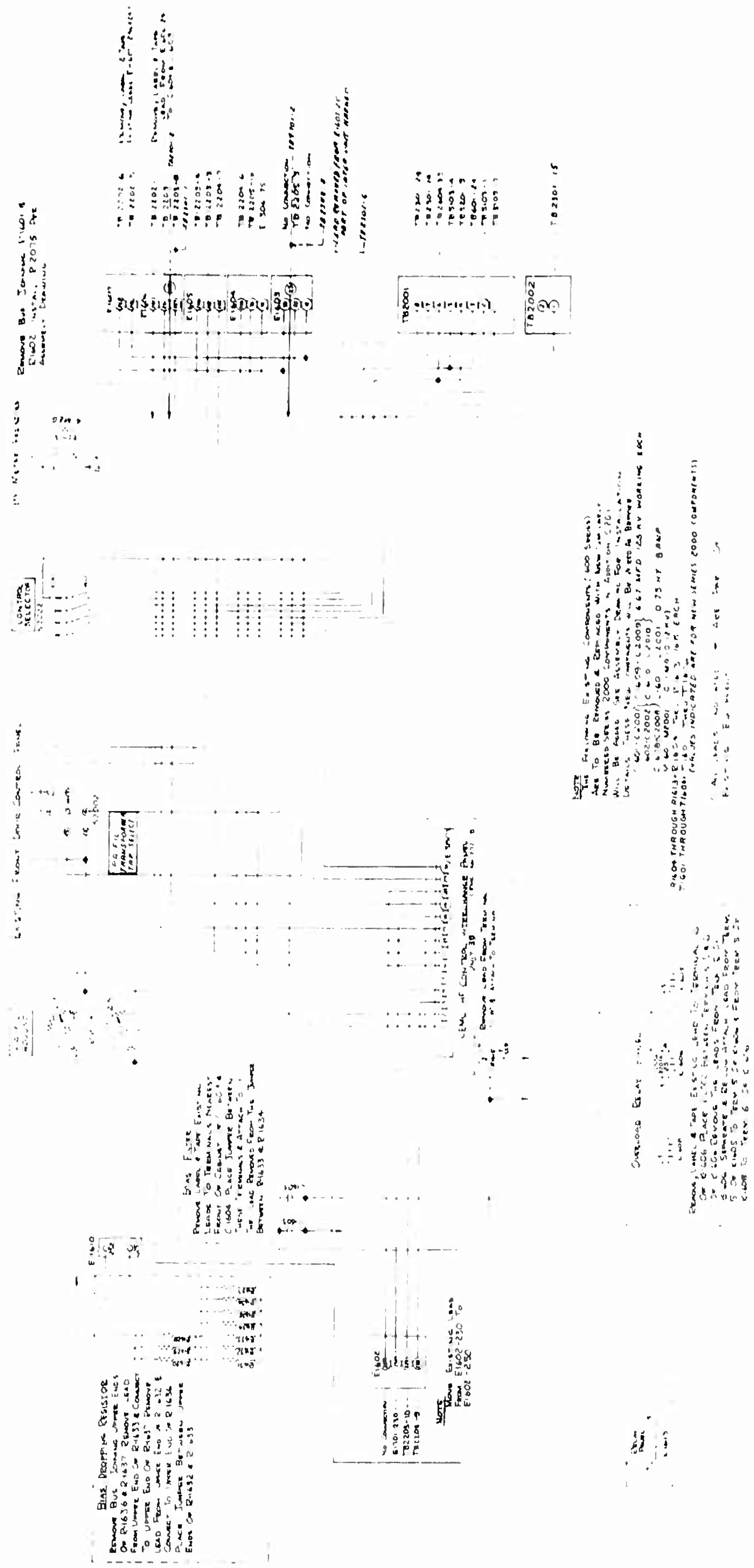


Figure 154. Schematic Diagram, 10-Kv Rectifier.

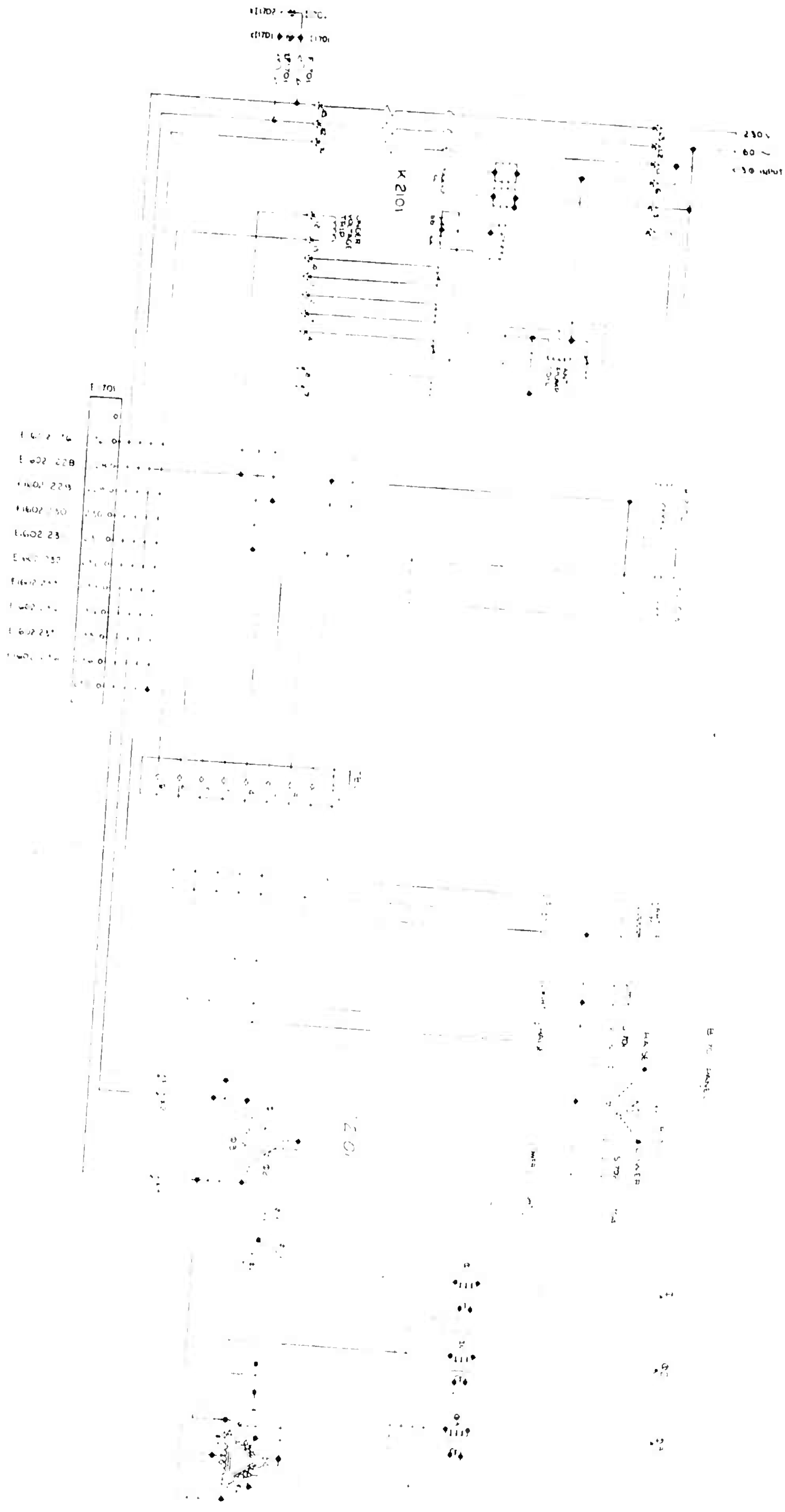


Figure 155. Schematic Diagram, 10-Kv Power Control.

	UNIT NO	DESCRIPTION
1	FRT26-3	POWER SUPPLY ASSY PP-1088/FRT-26
2	FRT26-5	RADIO TRANSMITTER T-454/ FRT-26
3	22	ALTERNATE 40 KW AMPLIFIER
4	20	POWER SUPPLY FOR 40 KW ALT AMP
5	FRT26-4	POWER TRANSFORMER TF-196/FRT-26
6	49	POWER SUPPLY CONTROL-C1402/FRT-26
7	17	POWER TRANSFORMER TF-197/FRT-26
8	17	POWER CONTROL C598/FRT-6
9	25	300 KW HV RECT NO 1
10	24	300 KW HV RECT NO 2
11	26	300 KW CONTROL
12	5	300 KW RF AMPLIFIER
13	6	300 KW OUTPUT NETWORK
14	31	300 KW POWER DISTRIBUTION
15	31	300 KW PLATE REGULATOR
16	31	300 KW FILAMENT REGULATOR
17	31	300 KW STEP DOWN TRANSFORMER
18	27	300 KW FILTER CONDENSER RACK
19	27	300 KW PLATE TRANSFORMER
20	27	300 KW CHOKE
21	47	300 KW PHANTOM ANTENNA
22	28	300 KW COOLER FOR PHANT ANT.
23	28	300 KW COOLER
24	28	BLOWER FOR PHANTOM ANTENNA COOLER
25	28	BLOWER FOR 300 KW COOLER
26	28	PUMP FOR PHANTOM ANTENNA COOLER
27	28	PUMP FOR 300 KW COOLER
28	28	WATER TANK-1400 GAL
29	27	300 KW KIRK KEY INTERLOCK TRANS BOX
30		DISTORTION MEASURING EQUIPMENT
31		T409/FRC-30 RADIO TRANSMITTER
32		T409/FRC-30 LINE REGULATOR

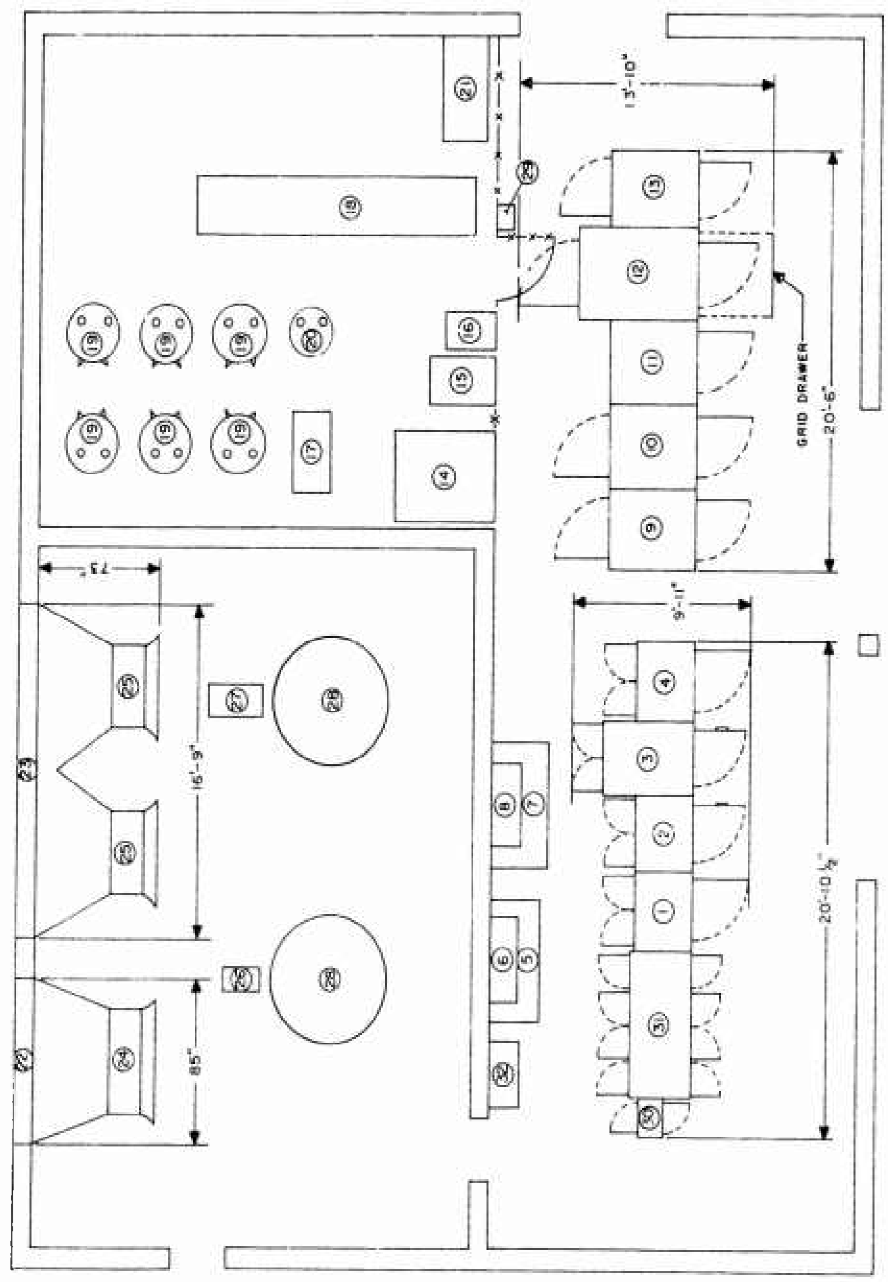


Figure 156. Typical Equipment Layout, Radio Transmitting Set AN/FRT-33 (XC-1)

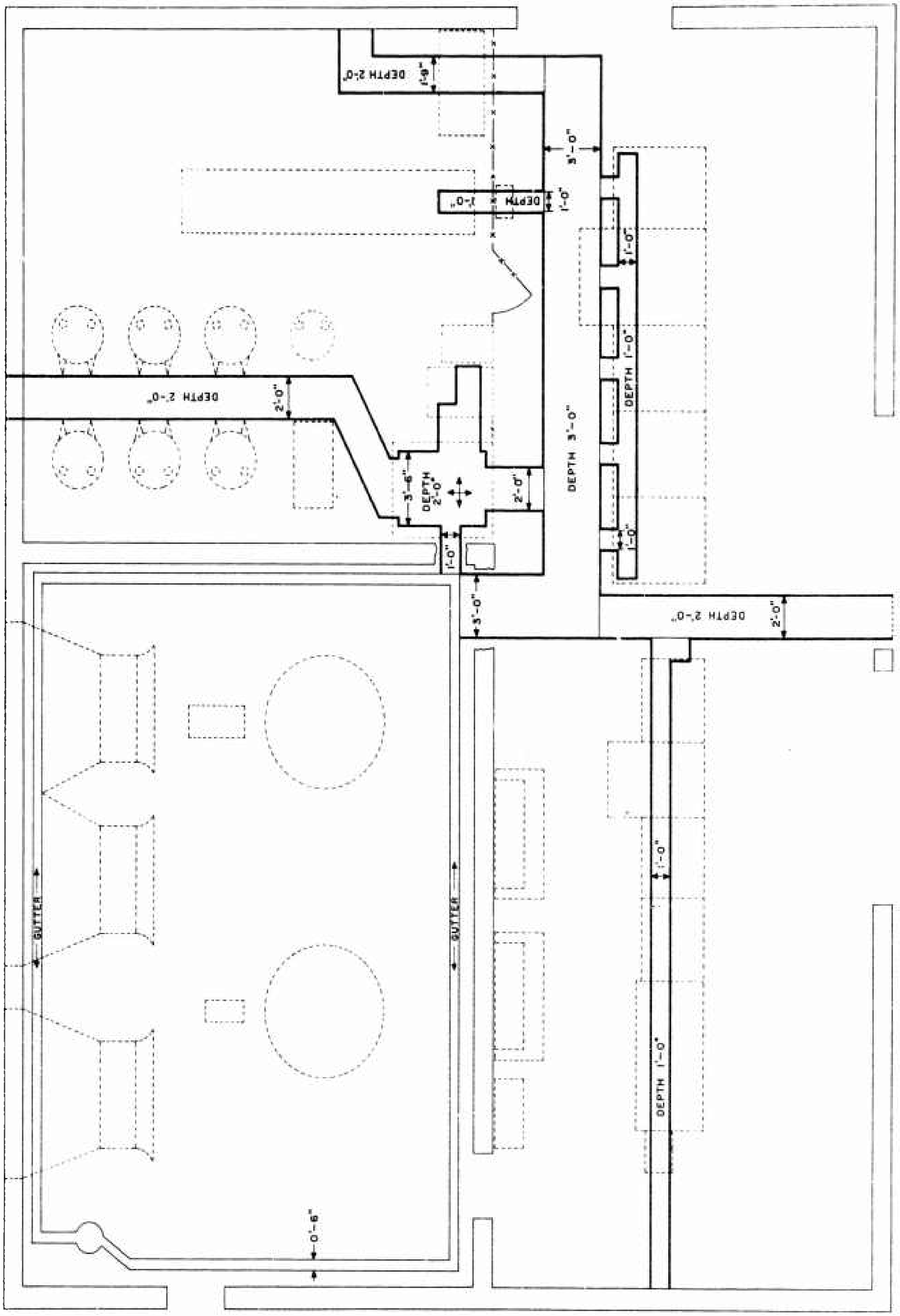


Figure 157. Typical Trench Layout, Radio Transmitting Set AN/FRT-33 (XC-1).

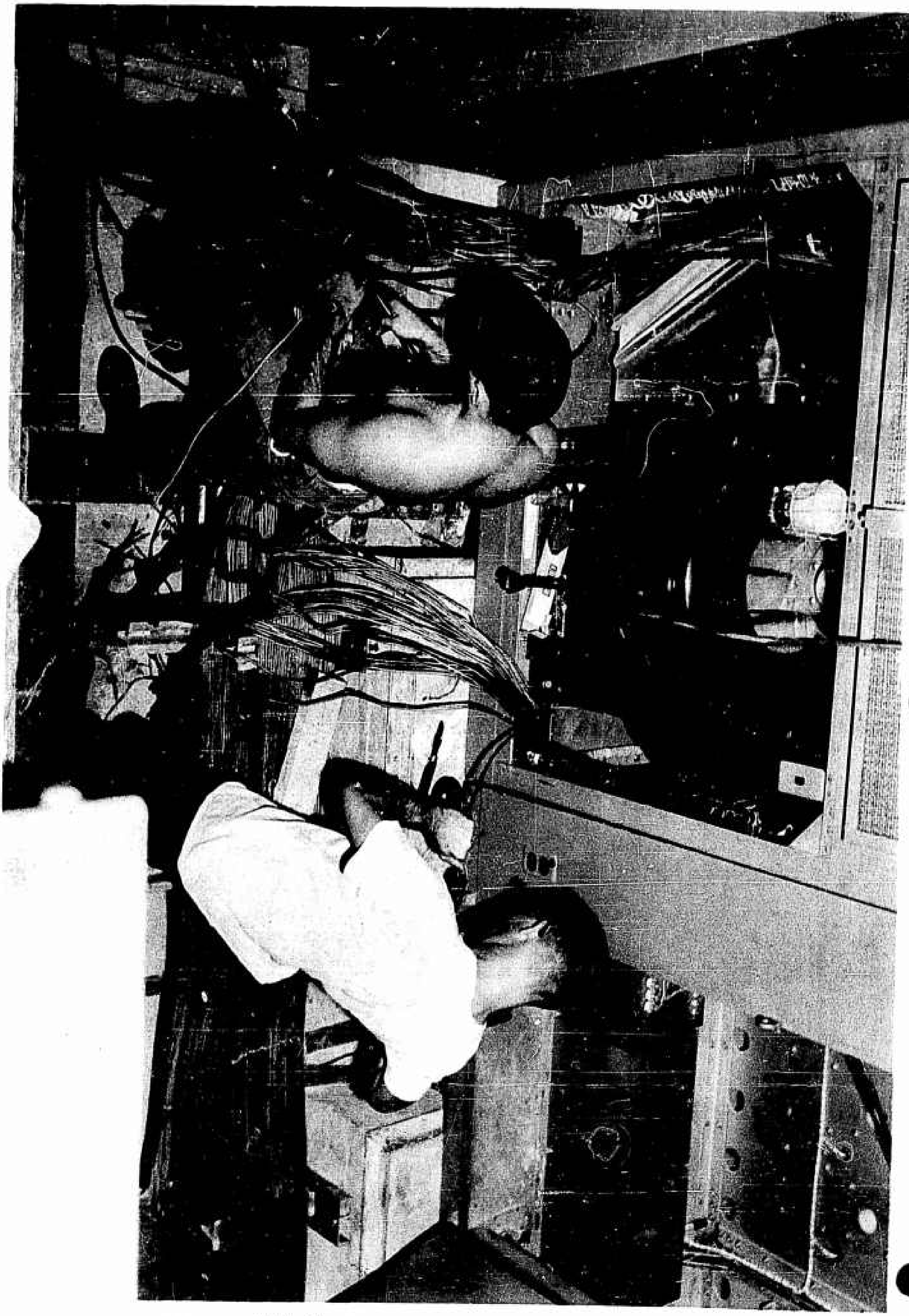


Figure 158. Terminating Wires, Rear of Control Unit.

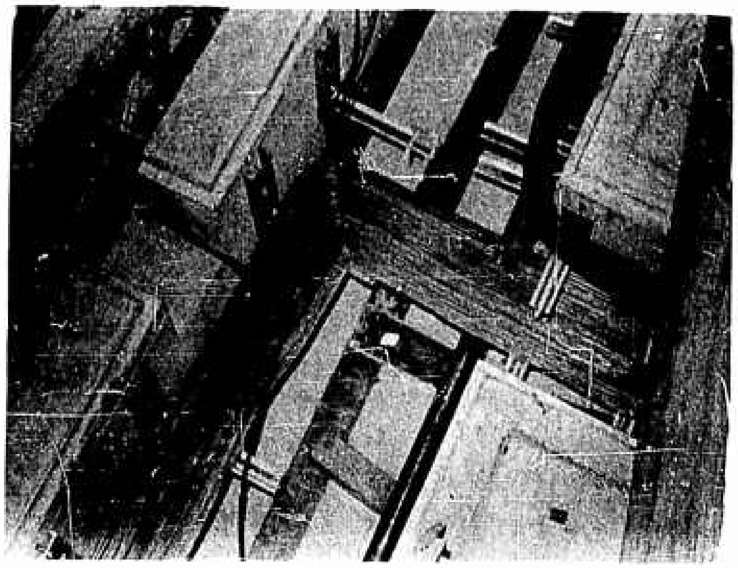


Figure 159. Trench Wiring, Distribution Unit to Main Trench.

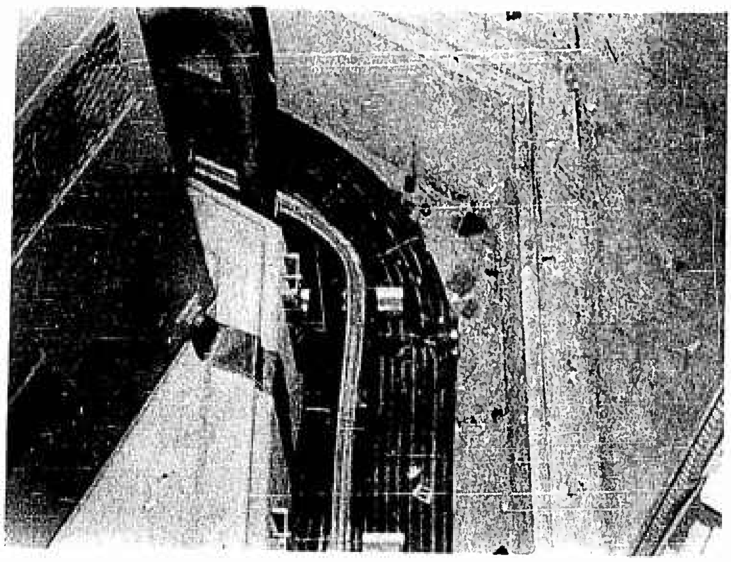


Figure 160. Trench Wiring, to Plate Transformers.

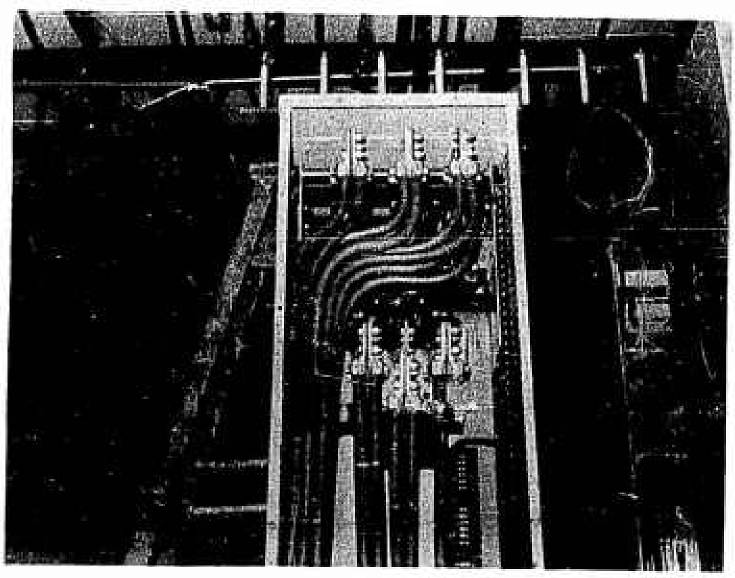


Figure 161. Plate Regulator, Rear View, Cover Removed.

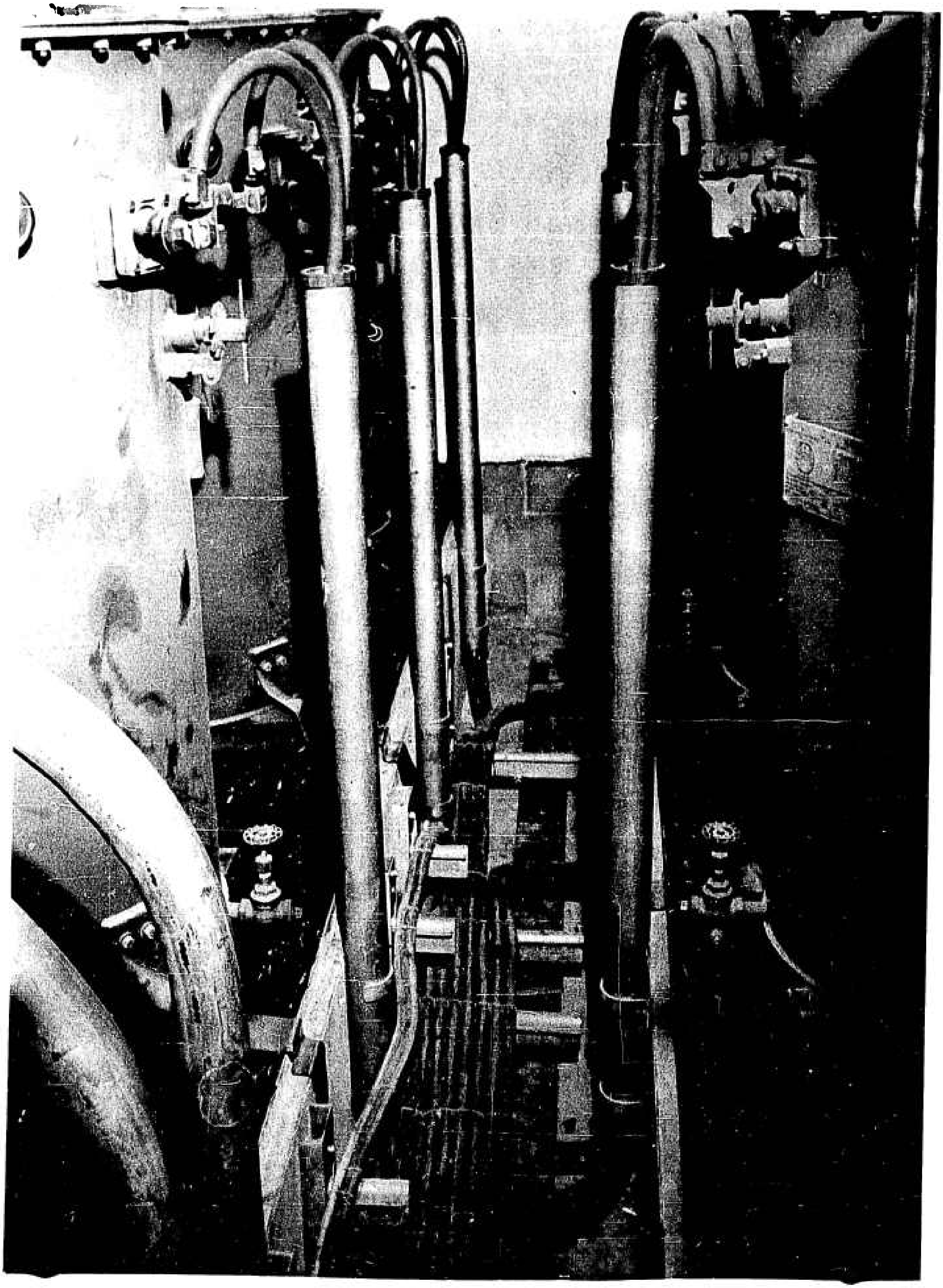


Figure 162. Trench Wiring, Hv Transformers.

Figure 163. High Voltage Buswork in Power Vault.

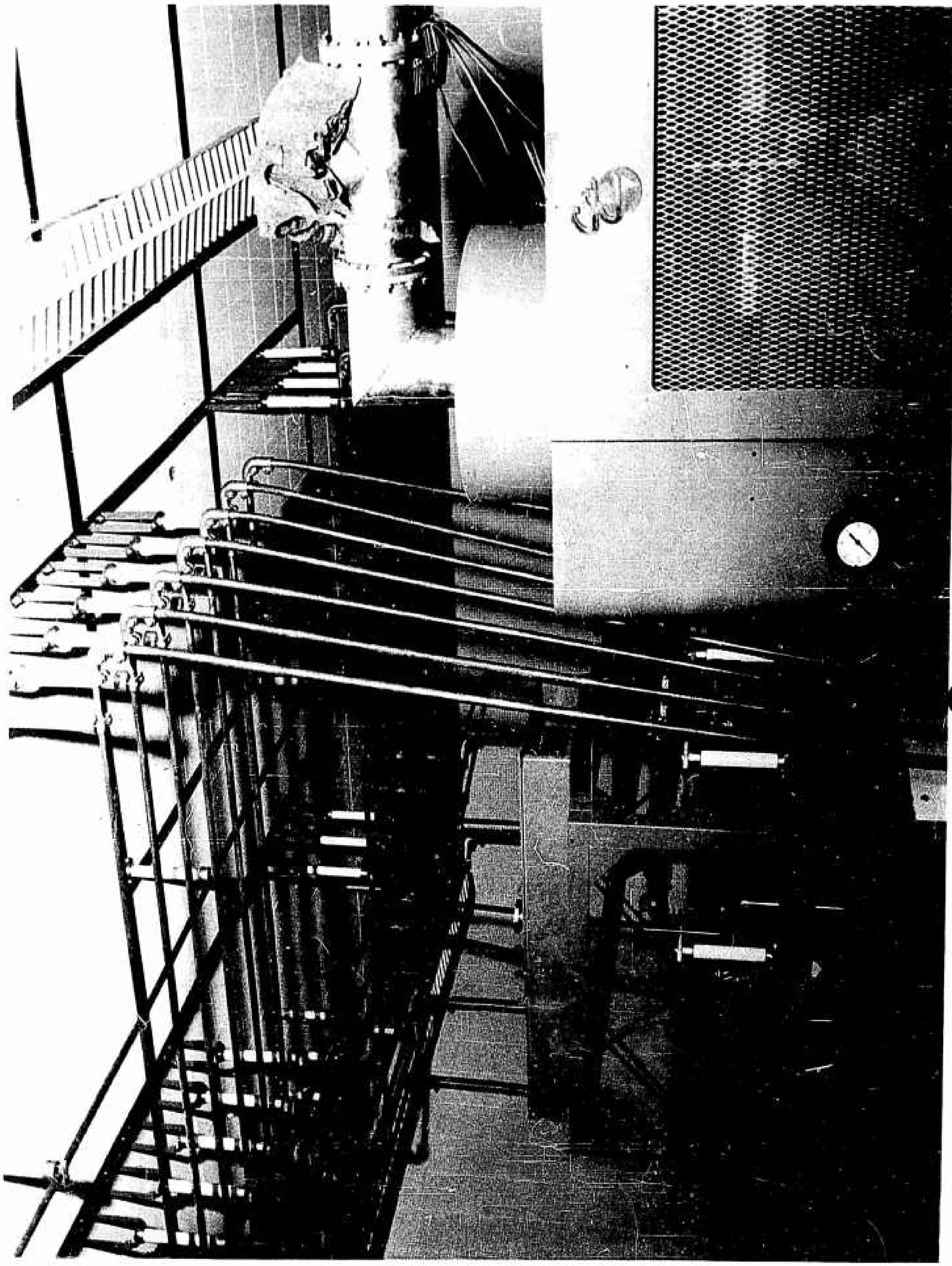


Figure 164. Overhead Bus in Power Vault.

Figure 165. Operating Room, Overhead Bus.

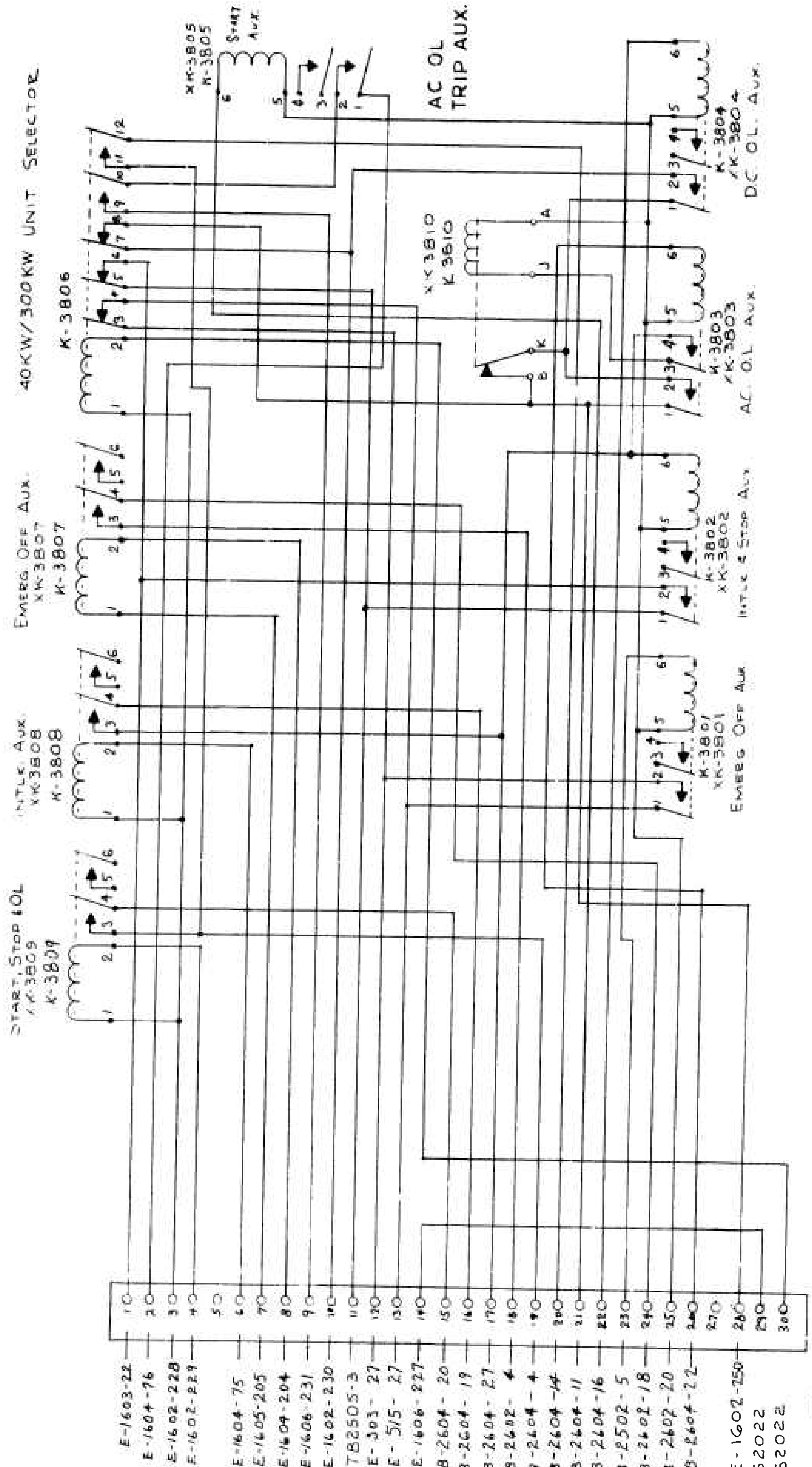


Figure 166. Schematic Diagram, Control Interchange Panel.

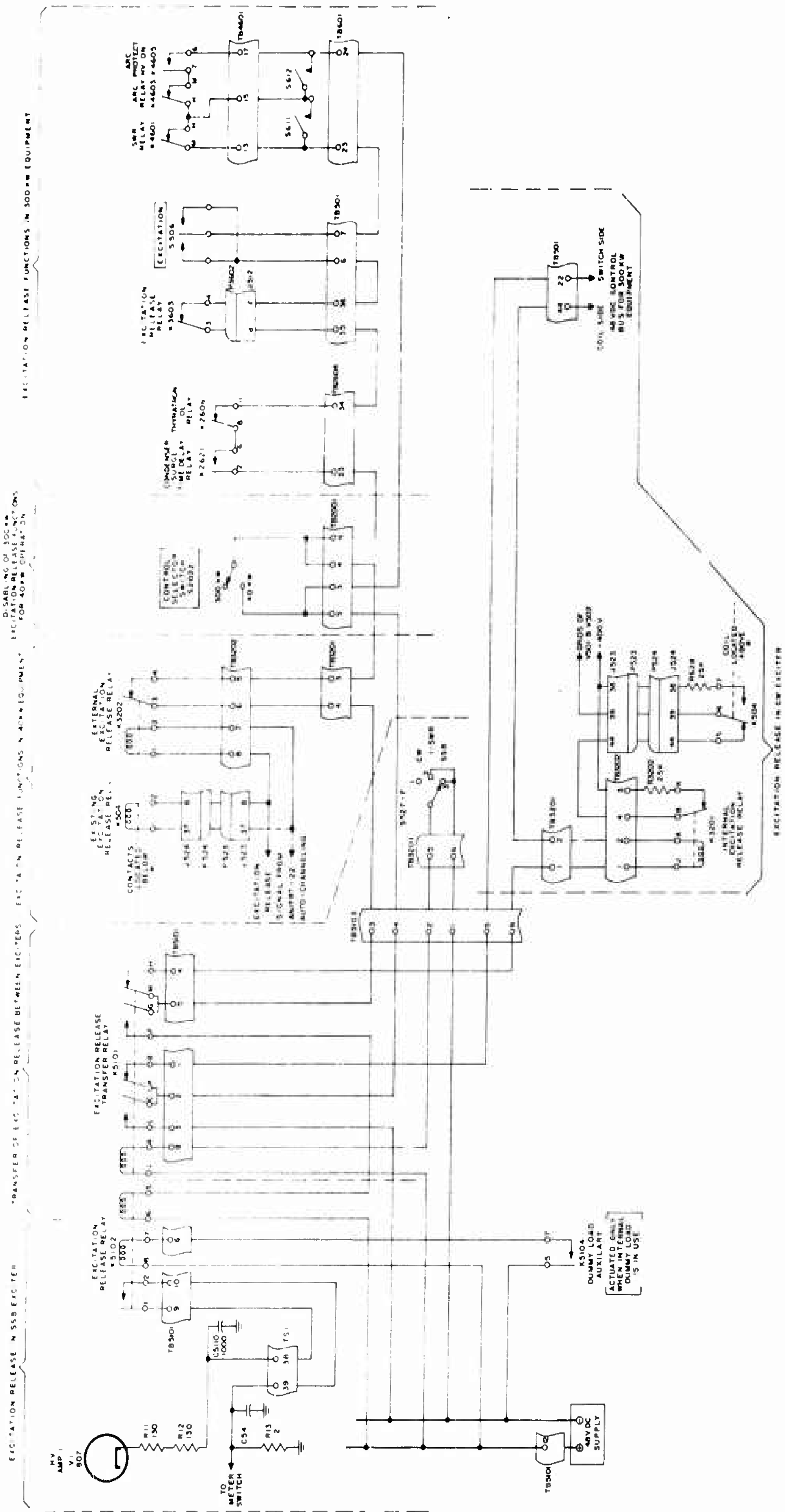
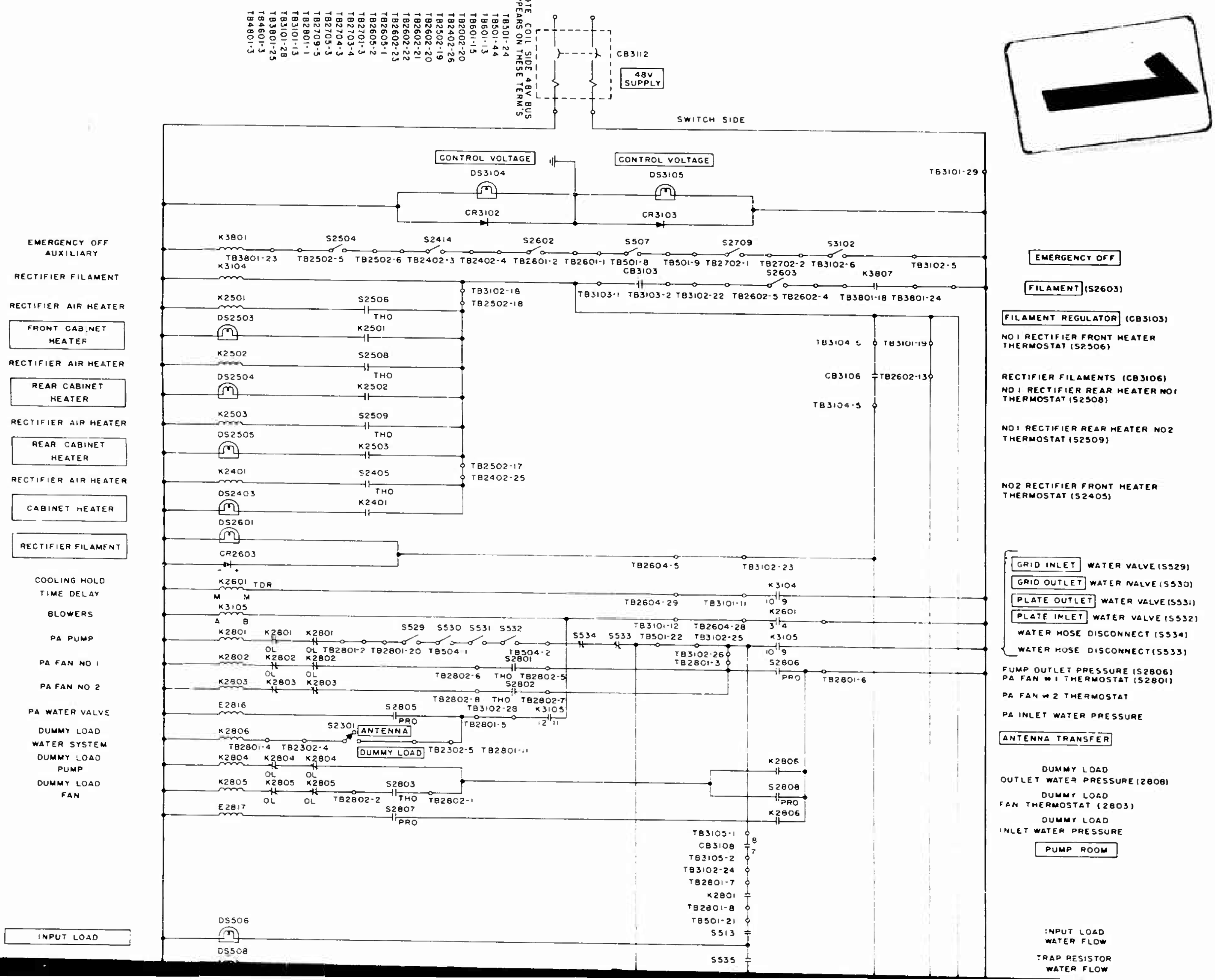
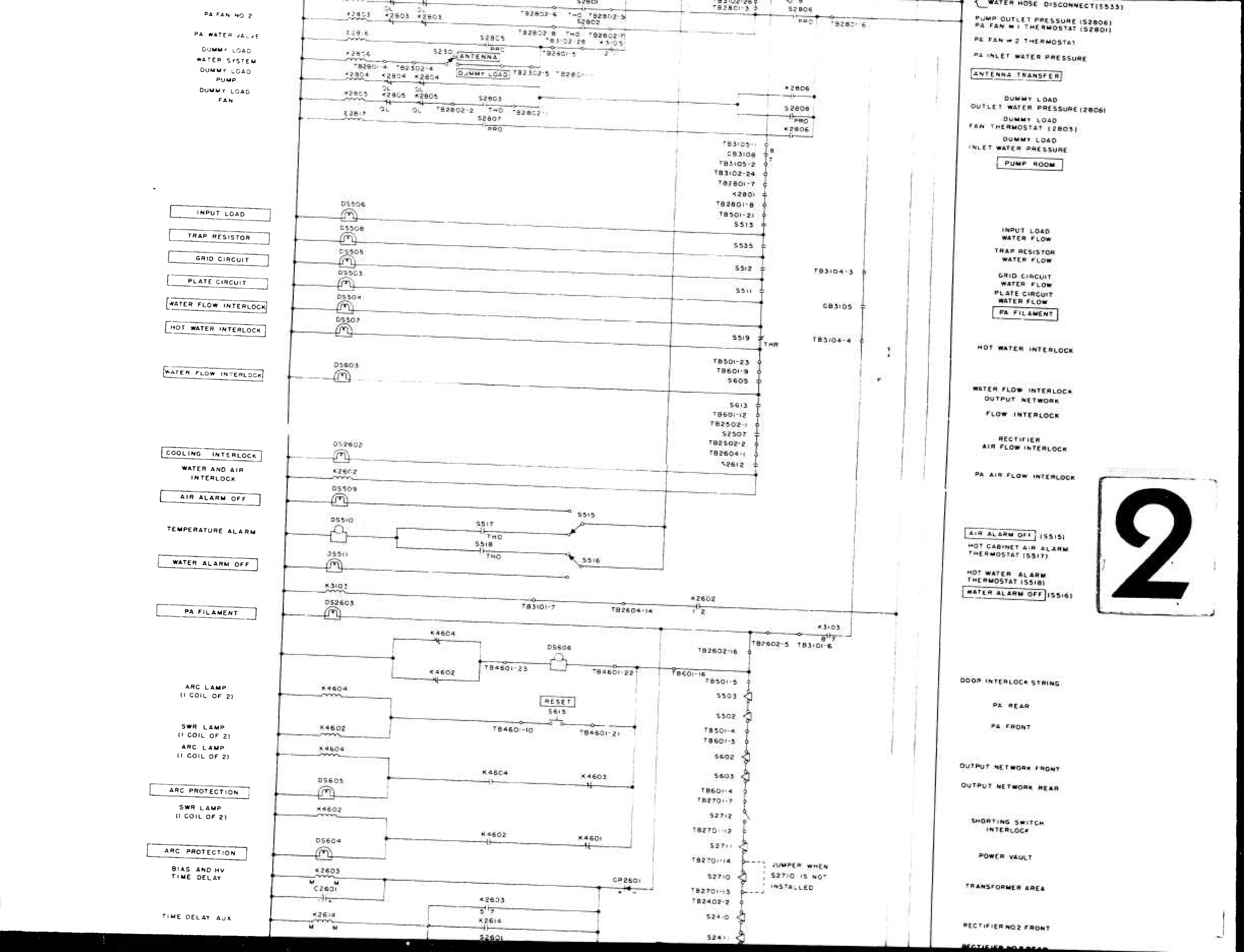
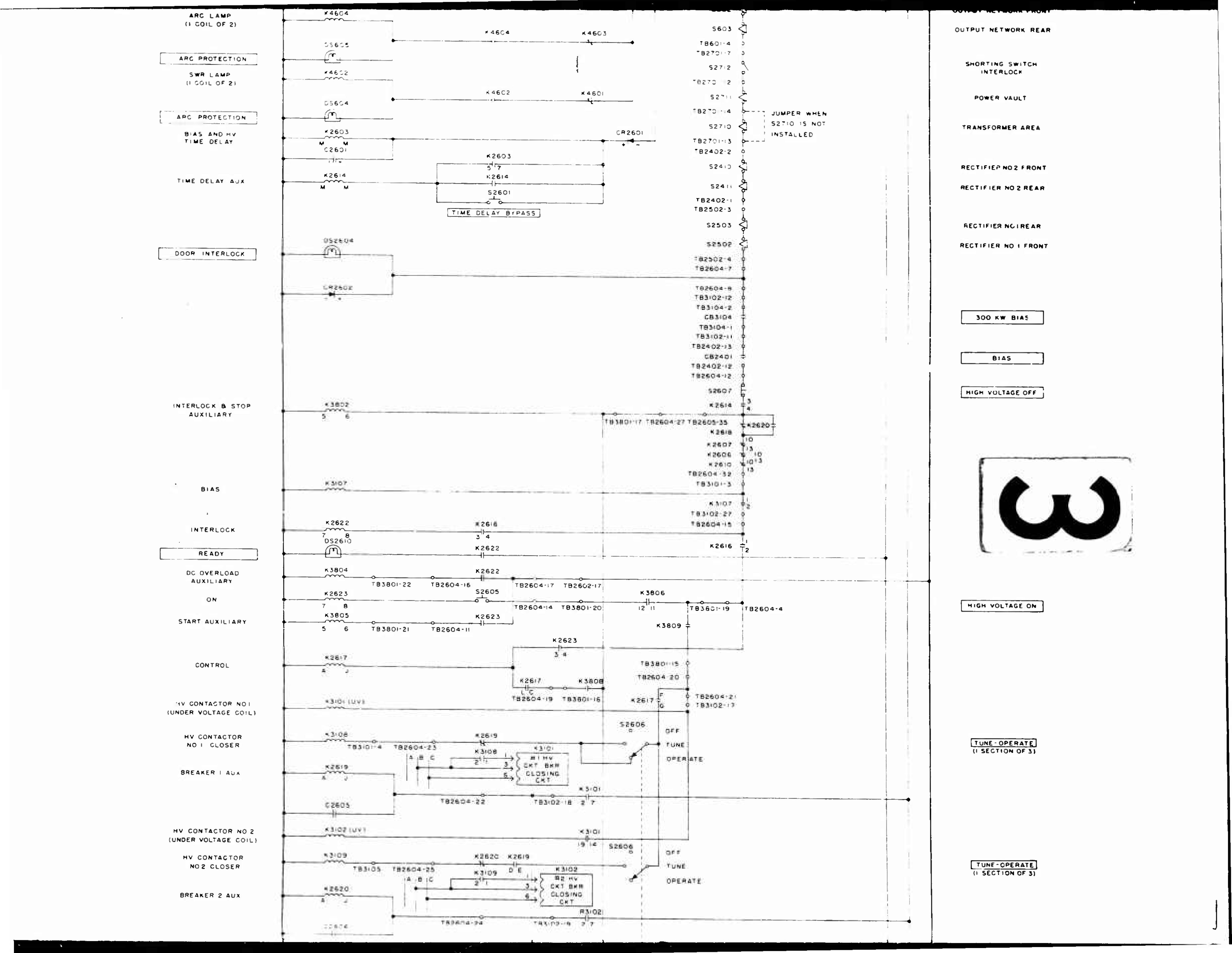


Figure 167. Simplified Schematic Diagram, Excitation Release Circuit.


1
NOTE COIL SIDE 48V BUS APPEARS ON THESE TERM'S
TB501-24
TB501-44
TB601-13
TB601-15
TB2002-20
TB2402-26
TB2502-19
TB2602-20
TB2602-21
TB2602-22
TB2602-23
TB2605-1
TB2605-2
TB2701-3
TB2703-4
TB2704-3
TB2705-3
TB2709-5
TB2801-1
TB3101-13
TB3101-28
TB3801-25
TB4601-3
TB4801-3
CB3112
48V SUPPLY
SWITCH SIDE
CONTROL VOLTAGE
DS3104
CR3102
CONTROL VOLTAGE
DS3105
CR3103
TB3101-29
EMERGENCY OFF AUXILIARY
RECTIFIER FILAMENT
RECTIFIER AIR HEATER
FRONT CABINET HEATER
RECTIFIER AIR HEATER
REAR CABINET HEATER
RECTIFIER AIR HEATER
REAR CABINET HEATER
RECTIFIER AIR HEATER
CABINET HEATER
RECTIFIER FILAMENT
COOLING HOLD
TIME DELAY
BLOWERS
PA PUMP
PA FAN NO 1
PA FAN NO 2
PA WATER VALVE
DUMMY LOAD WATER SYSTEM
DUMMY LOAD PUMP
DUMMY LOAD FAN
INPUT LOAD
K3801
TB3801-23
K3104
S2504
TB2502-5
TB2502-6
S2414
TB2402-3
TB2402-4
S2602
TB2601-2
TB2601-1
S507
TB501-8
CB3103
TB501-9
S2709
TB2702-1
TB2702-2
S2603
S3102
TB3102-6
K3807
TB3102-5
TB3102-18
TB2502-18
TB3103-1
TB3103-2
TB3102-22
TB2602-5
TB2602-4
TB3801-18
TB3801-24
K2501
S2506
THO
DS2503
K2501
K2502
S2508
THO
DS2504
K2502
K2503
S2509
THO
DS2505
K2503
TB2502-17
TB2402-25
K2401
S2405
THO
DS2403
K2401
DS2601
CR2603
TB3104-5
TB3101-19
CB3106
TB2602-13
TB3104-5
TB2604-5
TB3102-23
K2601 TDR
K3104
TB2604-29
TB3101-11
K3105
K2601
K2801
K2801
K2801
S529
S530
S531
S532
OL
TB2801-2
TB2801-20
TB504-1
TB504-2
S2801
S534
S533
TB3101-12
TB501-22
TB2604-28
TB3102-25
K3105
K2802
K2802
K2802
TB3102-26
TB2801-3
S2806
PRO
TB2801-6
K2803
K2803
K2803
TB2802-6
THO
TB2802-5
S2802
TB2802-8
THO
TB2802-7
E2816
S2805
PRO
TB3102-28
K3105
TB2801-5
K2806
S2301
ANTENNA
DUMMY LOAD
TB2801-4
TB2302-4
TB2302-5
TB2801-11
K2804
K2804
K2804
K2805
K2805
K2805
S2803
THO
TB2802-2
TB2802-1
E2817
S2807
PRO
K2806
S2808
PRO
K2806
TB3105-1
CB3108
TB3105-2
TB3102-24
TB2801-7
K2801
TB2801-8
TB501-21
S513
S535
DS506
DS508
EMERGENCY OFF
FILAMENT (S2603)
FILAMENT REGULATOR (CB3103)
NO 1 RECTIFIER FRONT HEATER THERMOSTAT (S2506)
RECTIFIER FILAMENTS (CB3106)
NO 1 RECTIFIER REAR HEATER NO 1 THERMOSTAT (S2508)
NO 1 RECTIFIER REAR HEATER NO 2 THERMOSTAT (S2509)
NO 2 RECTIFIER FRONT HEATER THERMOSTAT (S2405)
GRID INLET WATER VALVE (S529)
GRID OUTLET WATER VALVE (S530)
PLATE OUTLET WATER VALVE (S531)
PLATE INLET WATER VALVE (S532)
WATER HOSE DISCONNECT (S534)
WATER HOSE DISCONNECT (S533)
PUMP OUTLET PRESSURE (S2806)
PA FAN #1 THERMOSTAT (S2801)
PA FAN #2 THERMOSTAT
PA INLET WATER PRESSURE
ANTENNA TRANSFER
DUMMY LOAD OUTLET WATER PRESSURE (2808)
DUMMY LOAD FAN THERMOSTAT (2803)
DUMMY LOAD INLET WATER PRESSURE
PUMP ROOM
INPUT LOAD WATER FLOW
TRAP RESISTOR WATER FLOW



PA FAN NO 2
PA WATER VALVE
DUMMY LOAD WATER SYSTEM
DUMMY LOAD PUMP
DUMMY LOAD FAN
INPUT LOAD
TRAP RESISTOR
GRID CIRCUIT
PLATE CIRCUIT
WATER FLOW INTERLOCK
HOT WATER INTERLOCK
WATER FLOW INTERLOCK
COOLING INTERLOCK
WATER AND AIR INTERLOCK
AIR ALARM OFF
TEMPERATURE ALARM
WATER ALARM OFF
PA FILAMENT
ARC LAMP (1 COIL OF 2)
SWR LAMP (1 COIL OF 2)
ARC LAMP (1 COIL OF 2)
ARC PROTECTION
SWR LAMP (1 COIL OF 2)
ARC PROTECTION
BIAS AND HV TIME DELAY
TIME DELAY AUX
ANTENNA
DUMMY LOAD
RESET
S615
JUMPER WHEN S2710 IS NOT INSTALLED
WATER HOSE DISCONNECT (S535)
PUMP OUTLET PRESSURE (S2806)
PA FAN # 1 THERMOSTAT (S2801)
PA FAN # 2 THERMOSTAT
PA INLET WATER PRESSURE
ANTENNA TRANSFER
DUMMY LOAD OUTLET WATER PRESSURE (2806)
DUMMY LOAD FAN THERMOSTAT (2803)
DUMMY LOAD INLET WATER PRESSURE
PUMP ROOM
INPUT LOAD WATER FLOW
TRAP RESISTOR WATER FLOW
GRID CIRCUIT WATER FLOW
PLATE CIRCUIT WATER FLOW
PA FILAMENT
HOT WATER INTERLOCK
WATER FLOW INTERLOCK OUTPUT NETWORK
FLOW INTERLOCK
RECTIFIER AIR FLOW INTERLOCK
PA AIR FLOW INTERLOCK
AIR ALARM OFF (S515)
HOT CABINET AIR ALARM THERMOSTAT (S517)
HOT WATER ALARM THERMOSTAT (S518)
WATER ALARM OFF (S516)
DOOR INTERLOCK STRING
PA REAR
PA FRONT
OUTPUT NETWORK FRONT
OUTPUT NETWORK REAR
SHORTING SWITCH INTERLOCK
POWER VAULT
TRANSFORMER AREA
RECTIFIER NO 2 FRONT
2



ARC LAMP (1 COIL OF 2)
ARC PROTECTION
SWR LAMP (1 COIL OF 2)
ARC PROTECTION
BIAS AND HV TIME DELAY
TIME DELAY AUX
DOOR INTERLOCK
INTERLOCK & STOP AUXILIARY
BIAS
INTERLOCK
READY
DC OVERLOAD AUXILIARY
ON
START AUXILIARY
CONTROL
HV CONTACTOR NO 1 (UNDER VOLTAGE COIL)
HV CONTACTOR NO 1 CLOSER
BREAKER 1 AUX
HV CONTACTOR NO 2 (UNDER VOLTAGE COIL)
HV CONTACTOR NO 2 CLOSER
BREAKER 2 AUX
TIME DELAY BYPASS
JUMPER WHEN S2710 IS NOT INSTALLED
#1 HV CKT BKR CLOSING CKT
#2 HV CKT BKR CLOSING CKT
OFF
TUNE
OPERATE
OUTPUT NETWORK REAR
SHORTING SWITCH INTERLOCK
POWER VAULT
TRANSFORMER AREA
RECTIFIER NO 2 FRONT
RECTIFIER NO 2 REAR
RECTIFIER NO 1 REAR
RECTIFIER NO 1 FRONT
300 KW BIAS
BIAS
HIGH VOLTAGE OFF
HIGH VOLTAGE ON
TUNE-OPERATE (1 SECTION OF 3)
TUNE-OPERATE (1 SECTION OF 3)
3

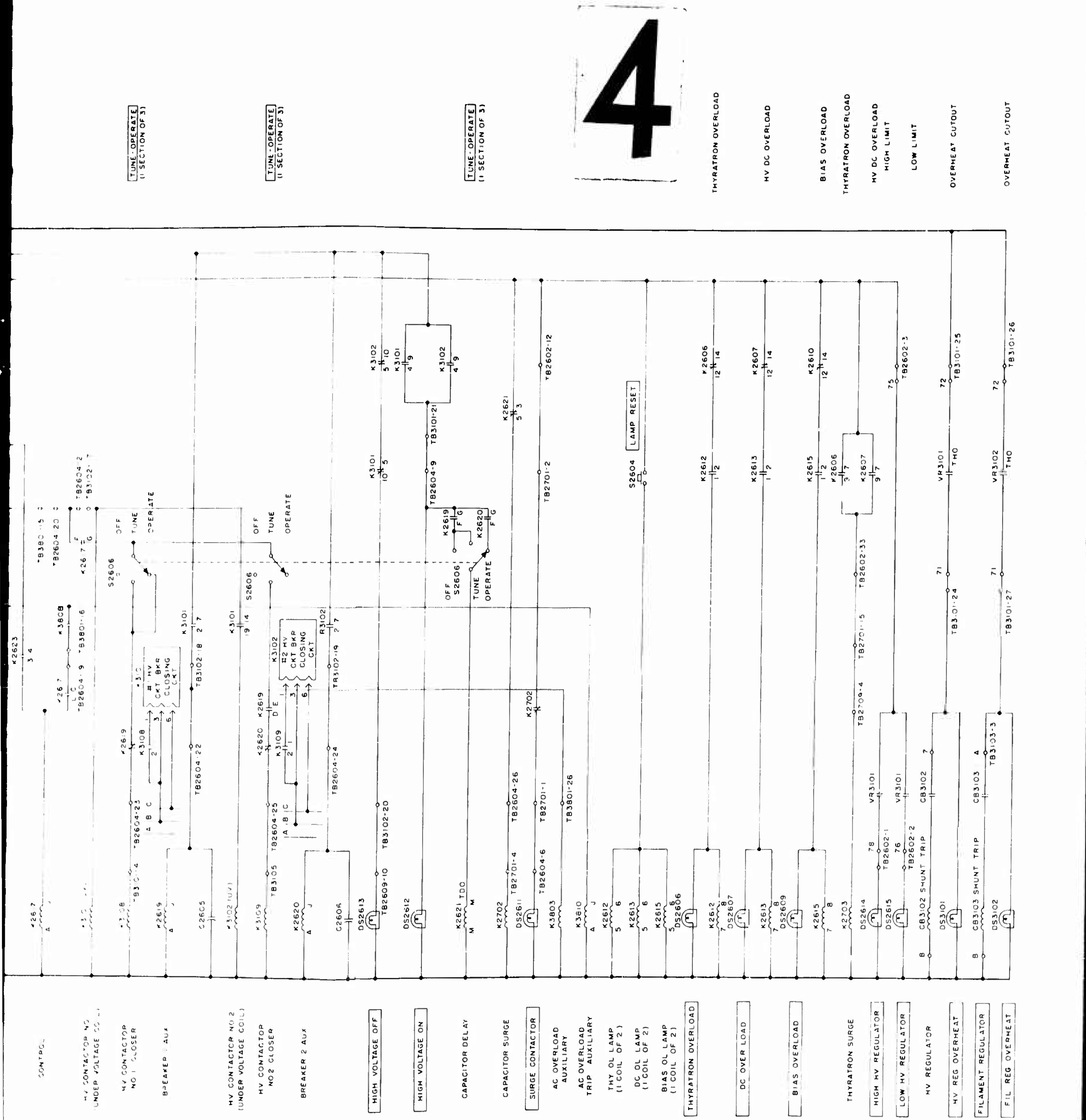


Figure 168. Ladder Diagram, Power Control Circuit.

1.7 Engineering Notes and Data

PRELIMINARY COLD MEASUREMENT DATA ON AN/FRT-26

Cold measurement techniques, employing spurious analyzing equipment, indicated the following modifications to the AN/FRT-26 would be required:

First Multiplier Plate Tuning

Change inductor to increase frequency range from 13.25 Mc to 15.15 Mc.

Second Multiplier Plate Tuning

Change tuning capacitor, C517, to reduce sharpness of tuning at high end of band. (An inductor modification should solve the same problem.)

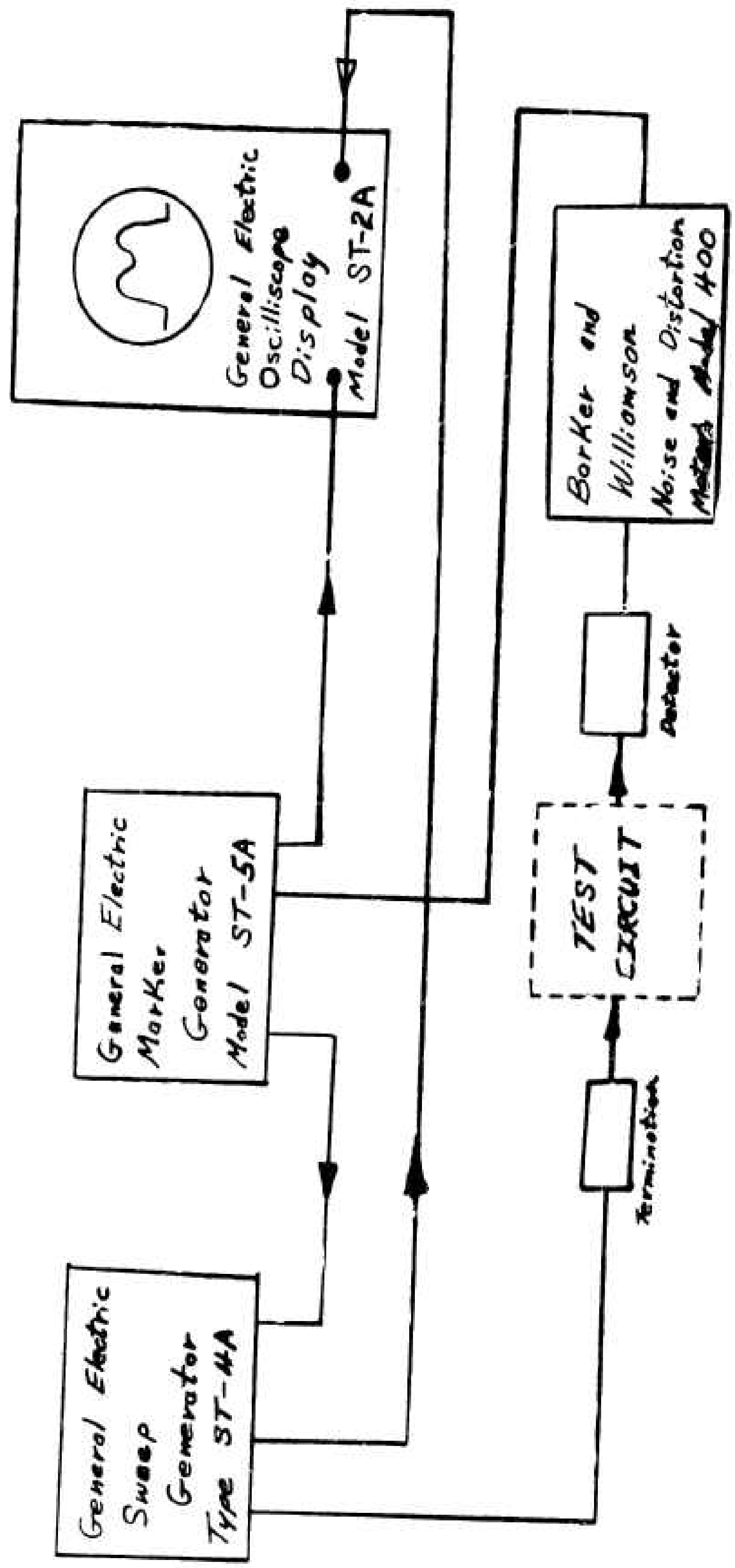
Driver Plate Tuning

Short out the two high frequency turns of network inductor, L509, and add a fixed inductor in series. This would allow capacity tuning over the range of 20 Mc to 30.3 Mc. A high Q resonanate circuit capable of causing a parasitic oscillation was recorded at 26 Mc.

Intermediate Power Amplifier

General clean up of spurious resonances by modifying neutralizing circuits and parasitic suppressors.

COLD MEASUREMENT SPURIOUS ANALYSING EQUIPMENT



ACTUAL MODIFICATIONS TO AN/FRT-26

Grid Circuit

1. Added series inductance per CEMC Dwg. No. 18982-B from C-526 to L-509.

2. Modified L-509 by soldering 1/16" copper strap from "HOT" end of coil around 1-1/8 turns on inside edge of existing coil per CEMC Dwg. No. 18981-A. Added .032 copper strap 1" wide from inside end turn to coil form end block per CEMC Dwg. No. 18975-A.

3. Added low inductance lead from grid side of C-526 to "HOT" side of C-533 per CEMC Dwg. No. 18988-A.

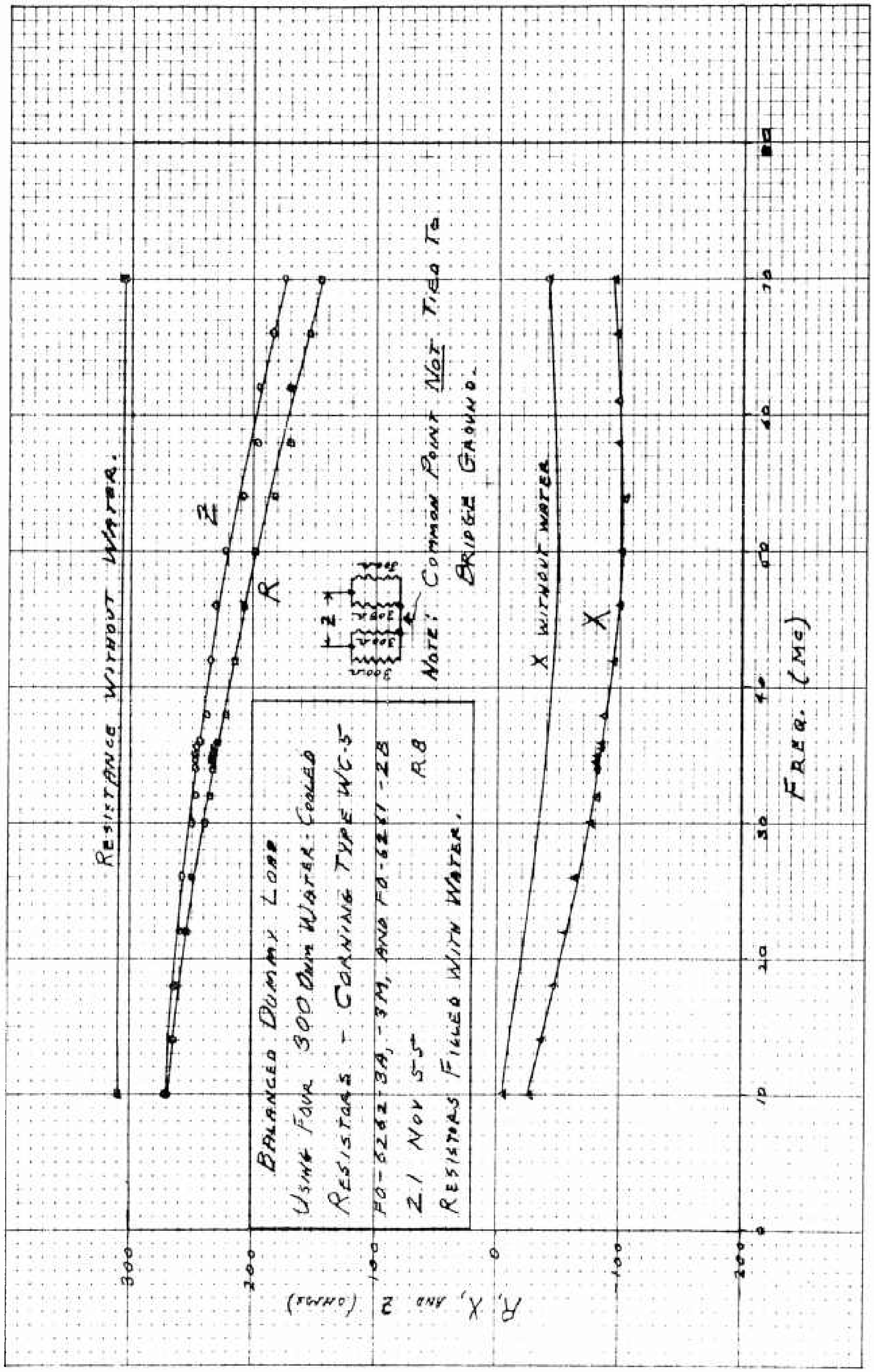
4. Replaced two leads from C-534 to E-530 and C-533 to E-533 with low inductance leads of 1" by .032 copper strap per CEMC Dwg. No. 18989-A.

5. Added low inductance ground lead from C-534 condenser frame to C-535 condenser frame per CEMC Dwg. No. 18990-A.

6. Installed two parasitic suppressor assemblies. These replace E-545.1 and E-545.2 single side band coupling links. The assemblies contains 4 No. 31-60 fuse clamps, 2 1/2" X 1" ceramic stand-off and 2 20 ohm 4" Globar resistor with a 3 turn coil wound around each and clamped at both ends per CEMC Dwg. No. 18974-D.

Plate Circuit

1. Modified 3X2500 plate choke.
2. Added 400 ohm 8" Globar resistor across plate choke.
3. Added sampling pick up per CEMC Dwg. No. 18995-A.


BALANCED DUMMY LOAD
USING FOUR 300 OHM WATER COOLED
RESISTORS - CORNING TYPE WC-5
FO-6262-3A, -3M, AND FO-6261-2B
21 NOV 55 RB
RESISTORS FILLED WITH WATER.
RESISTANCE WITHOUT WATER.
Z
R
X WITHOUT WATER
X
NOTE: COMMON POINT NOT TIED TO BRIDGE GROUND.
FREQ. (MC)
R, X, AND Z (OHMS)
300
200
100
0
-100
-200
10
20
30
40
50
60
70
80

Preliminary Tuning Data on AN/FRT-26

FRT-26 AND ALTERNATE AMPLIFIER DIAL

FOR 40 KW INTO STAINLESS

OUTPUT FREQUENCY	M.O. FREQ.	1ST MULT PLATE	2ND MULT PLATE	DRIVER PLATE	P.A. PLATE	P.A. LOADING	ANT TUNING	E_B P.A.	I_B P.A.	LEFT LINE CURR.	RIGHT LINE CURR.	INPUT TUNING	PLATE TUNING
	TUNING DIAL SETTINGS							METERS				DIAL	
3.9	3.900	138	62	54	15	748	138	5KV	3.4	7.5	9.0	147	000
4	2.000	167[A]	87	84	47	743	000	5KV	3.75	7.6	9.0	42	26
5	2.500	382[A]	287	290	234	543	117	5KV	3.8	5.3	5.8	30	140
6	5.000	526[A]	419	425	364	510	254	5KV	3.75	5.5	5.5	401	248
7	3500	630[A]	516	512	458	504	350	5KV	3.65	8.3	8.5	496	308
8	4.000	703[A]	582	560	527	816	595	4.9KV	3.95	4.8	4.7	552	350
9	2.250	285[A]	640[A]	619	589	456	484	5KV	3.75	7.2	7.0	600	400
10	2500	380[A]	683[A]	654	636	449	540	5KV	3.85	5.0	4.8	642	452
11	2.750	458[A]	721[A]	685	677	476	584	4.9KV	4.0	4.5	4.1	678	473
12	3000	528[A]	751[A]	708	710	696	631	4.95KV	3.9	8.0	5.7	688	495
13	3.250	580[A]	778[A]	729	737	822	648	4.95KV	3.95	9.4	7.4	706	525
14	3.500	630[A]	798[A]	749	763	601	802	4.9KV	4.05	3.8	3.8	772	560
15	3.750	670[A]	818[A]	764	786	680	710	4.95KV	3.7	8.0	6.2	758	570
16	4.000	706[A]	836[A]	777	804	678	732	4.95KV	3.8	8.0	6.0	778	584
17	2.833	736[B]	850[A]	791	821	678	753	5.0KV	3.7	8.5	6.5	796	603
18	3.000	765[B]	865[A]	803	835	608	780	4.9KV	3.9	8.6	6.3	820	628
19	3.166	792[B]	878[A]	812	848	616	794	4.95KV	3.85	9.3	6.9	838	640
20	3.333	816[B]	888[A]	824	866	548	782	4.95KV	3.8	10.0	8.7	818	647
21	3.500	832[B]	900[A]	837	878	440	800	4.95KV	3.9	8.6	8.0	812	664
22	3.666	855[B]	909[A]	845	891	438	817	4.95KV	3.8	6.5	6.2	808	685
23	3.833	872[B]	918[A]	852	902	556	828	4.95KV	3.9	7.8	7.0	836	690
24	4.000	888[B]	927[A]	863	917	547	845	4.9KV	3.9	4.4	4.4	826	700
25	3.125	904[C]	935[A]	873	926	623	855	4.9KV	4.0	4.0	3.5	839	720
26	3.250	917[C]	945[A]	880	937	698	858	4.95KV	3.8	8.2	6.7	870	737
27	3.375	929[C]	950[A]	887	948	747	866	4.95KV	3.8	8.4	6.6	878	743
28	3.500	941[C]	956[A]	900	950	800	883	4.8KV	4.0	3.4	6.0	877	760
29	3.625	952[C]	960[A]	910	971	754	884	4.95KV	3.0	8.8	5.4	892	772
30	3.750	962[C]	969[A]	921	981	993	921	4.95KV	3.8	5.5	5.5	875	788
31	3.875	973	974	968	992	1000	914	4.8KV	4.5	3.6	5.3	892	791

1. TRANSMITTER MULTIPLICATION NEVER EXCEEDS 8, - MULTIPLICATION IN
   - A. x 2 MULT
   - B. x 3 MULT.
   - C. x 4 MULT.
2. EXCITATION CONTROL IS SET TO PROVIDE APPROX. .4 AMPERES OF I.P.A. GRI
3. OUTPUT FREQ. AND M.O. FREQ. ARE IN MEGACYCLES.
4. DRIVER ANT. CAPACITY SWITCH WAS PLACED IN OFF POSITION EXCEPT AS NOTED.

reliminary Tuning Data on AN/FRT-26 and Alternate Amplifier

AND ALTERNATE AMPLIFIER DIAL SETTINGS AND METER READINGS, 4-30 MEGACYCLES

FOR 40 KW INTO STAINLESS STEEL SPRING DUMMY LOAD

METERS			DIALS			METERS						
I_B PA	LEFT LINE CURR.	RIGHT LINE CURR.	INPUT TUNING	PLATE TUNING	P.A. LOADING	I_G PA	E_P PA	I_B P.A.	E_C R.F.	E_B R.F.	POWER OUTPUT	NOT
3.4	7.5	9.0	147	000	172	.58	8.5KV	6.2	1100V	6600V	42 KW	ANT. CAP. SWITCH IN "ON
3.75	7.6	9.0	42	26	178	.6	8.5KV	6.4	1100V	6300V	46KW	1-ARC-OVER IN OUTPUT
3.8	5.3	5.8	30	140	409	.58	8.5KV	6.4	1020V	6700V	46KW	BACK CONTACTS ON
3.75	5.5	5.5	407	248	600	.6	8.5KV	6.5	1000V	6400V	48KW	OK
3.65	8.3	8.5	496	308	120	.59	8.5KV	6.5	1000V	6600V	46KW	LARGE SPIRAL STICK
3.95	4.8	4.7	552	350	338	.56	8.5KV	6.7	980V	6800V	46KW	ANT. CAP. SWITCH IN ON
3.75	7.2	7.0	600	400	450	.56	8.5KV	6.4	1000V	6700V	46KW	OK
3.85	5.0	4.8	642	452	350	.55	8.5KV	6.4	960V	6600V	47 KW	OK
4.0	4.5	4.1	678	473	300	.56	8.5KV	6.5	960V	6600V	45KW	OK
3.9	8.0	5.7	688	495	468	.6	8.5KV	6.4	1000V	6700V	46KW	UNABLE TO BALANC
3.95	9.4	7.4	706	525	549	.6	8.5KV	6.6	980V	6900V	47KW	UNABLE TO BALANC
4.05	3.8	3.8	772	560	453	.55	8.5KV	6.4	970V	6700V	46KW	BALUN TROUBLE PLACE AN IN GND.
3.7	8.0	6.2	758	570	432	.57	8.5KV	6.5	980V	6700V	46KW	PA PLATE BLOCKING ANT. CAP. SWITCH IN OFF
3.8	8.0	6.0	778	584	570	.55	8.5KV	6.6	950V	6600V	46KW	ARC-OVER FROM PA TO UPPER GND BLOC
3.7	8.5	6.5	796	603	629	.58	8.5KV	6.4	980V	6700V	46KW	OK
3.9	8.6	6.3	820	628	567	.58	8.5KV	6.4	1000V	6700V	46KW	OK
3.85	9.3	6.9	838	640	406	.54	8.5KV	6.4	960V	6600V	46KW	OK
3.8	10.0	8.7	818	647	558	.54	8.5KV	6.7	940V	6400V	46KW	BALUN ARC-OVER
3.9	8.6	8.0	812	664	614	.5	8.5KV	6.6	920V	6500V	46KW	OK
3.8	6.5	6.2	808	685	450	.49	8.5KV	6.2	870V	6500V	44 KW	OK
3.9	7.8	7.0	836	690	478	.50	8.5KV	6.6	920V	6500V	45KW	OK
3.9	4.4	4.4	826	700	580	.53	8.5KV	6.4	920V	6600V	45KW	OK
4.0	4.0	3.5	839	720	611	.50	8.5KV	6.2	920V	6700V	43KW	OK
3.8	8.2	6.7	870	737	479	.57	8.5KV	6.5	960V	6600V	45KW	OK
3.8	8.4	6.6	878	743	546	.50	8.5KV	6.5	920V	6600V	46KW	OK
4.0	3.4	6.0	877	760	642	.55	8.5KV	6.7	920V	6900V	46KW	PLATE CHOKE ARC-O 50Ω RESISTOR ACROSS 3
3.0	8.8	5.4	892	772	638	.55	8.5KV	6.4	920V	6900V	45KW	OK
3.8	5.5	5.5	875	788	460	.50	8.5KV	6.4	920V	7000V	45KW	OK
4.5	3.6	5.3	892	791	588	.50	8.5KV	6.5	880V	7000V	45KW	BALUN ARC-OVE

2

XCEEDS 8, - MULTIPLICATION IN ONE STAGE NEVER EXCEEDS 3.

PPROX. .4 AMPERES OF I.P.A. GRID CURRENT. SET FOR MAXIMUM CURRENT ABOVE 28 MEGACYCLES
GACYCLES.
IN OFF POSITION EXCEPT AS NOTED.

on AN/FRT-26 and Alternate Amplifier
...PLIFIER DIAL SETTINGS AND METER READINGS, 4-30 MEGACYCLES
STAINLESS STEEL SPRING DUMMY LOAD

DIALS			METERS						
INPUT TUNING	PLATE TUNING	P.A. LOADING	I_G PA	E_P PA	I_B P.A.	E_G R.F.	E_B R.F.	POWER OUTPUT	NOTES
147	000	172	.58	8.5KV	6.2	1100V	6600V	42KW	ANT. CAP. SWITCH IN "ON" POSITION
42	26	178	.6	8.5KV	6.4	1100V	6300V	46KW	1-ARC-OVER IN OUTPUT STAGE-RECLOSED OK
30	140	409	.58	8.5KV	6.4	1020V	6700V	46KW	BACK CONTACTS ON LARGE SPIRAL BURNING
407	248	600	.6	8.5KV	6.5	1000V	6400V	48KW	OK
496	308	120	.59	8.5KV	6.5	1000V	6600V	46KW	LARGE SPIRAL STICKING
552	350	338	.56	8.5KV	6.7	980V	6800V	46KW	ANT. CAP. SWITCH IN GND. POSITION OK
600	400	450	.56	8.5KV	6.4	1000V	6700V	46KW	OK
642	452	350	.55	8.5KV	6.4	960V	6600V	47KW	OK
678	473	300	.56	8.5KV	6.5	960V	6600V	45KW	OK
688	495	468	.6	8.5KV	6.4	1000V	6700V	46KW	UNABLE TO BALANCE LINE CURRENTS
706	525	549	.6	8.5KV	6.6	980V	6900V	47KW	UNABLE TO BALANCE LINE CURRENTS
772	560	453	.55	8.5KV	6.4	970V	6700V	46KW	BALUN TROUBLE PLACE ANT. CAPACITY SWITCH IN GND. POSITION
758	570	432	.57	8.5KV	6.5	980V	6700V	46KW	PA PLATE BLOCKING COND ARC-OVER ANT. CAP. SWITCH IN OFF POSITION AGAIN
778	584	570	.55	8.5KV	6.6	950V	6600V	46KW	ARC-OVER FROM PA PLATE CHIMNEY TO UPPER GND BLOCK
796	603	629	.58	8.5KV	6.4	980V	6700V	46KW	OK
820	628	567	.58	8.5KV	6.4	1000V	6700V	46KW	OK
838	640	406	.54	8.5KV	6.4	960V	6600V	46KW	OK
818	647	558	.54	8.5KV	6.7	940V	6400V	46KW	BALUN ARC-OVER
812	664	614	.5	8.5KV	6.6	920V	6500V	46KW	OK
808	685	450	.49	8.5KV	6.2	870V	6500V	44KW	OK
836	690	478	.50	8.5KV	6.6	920V	6500V	45KW	OK
876	700	580	.53	8.5KV	6.4	920V	6600V	45KW	OK
839	720	611	.50	8.5KV	6.2	920V	6700V	43KW	OK
870	737	479	.57	8.5KV	6.5	960V	6600V	45KW	OK
878	743	546	.50	8.5KV	6.5	920V	6600V	46KW	OK
877	760	642	.55	8.5KV	6.7	920V	6900V	46KW	PLATE CHOKE ARC-OVER FIXED BY 50Ω RESISTOR ACROSS 3 BOTTOM TURNS OF CHOKE
892	772	638	.55	8.5KV	6.4	920V	6900V	45KW	OK
875	788	460	.50	8.5KV	6.4	920V	7000V	45KW	OK
892	791	588	.50	8.5KV	6.5	880V	7000V	45KW	BALUN ARC-OVER

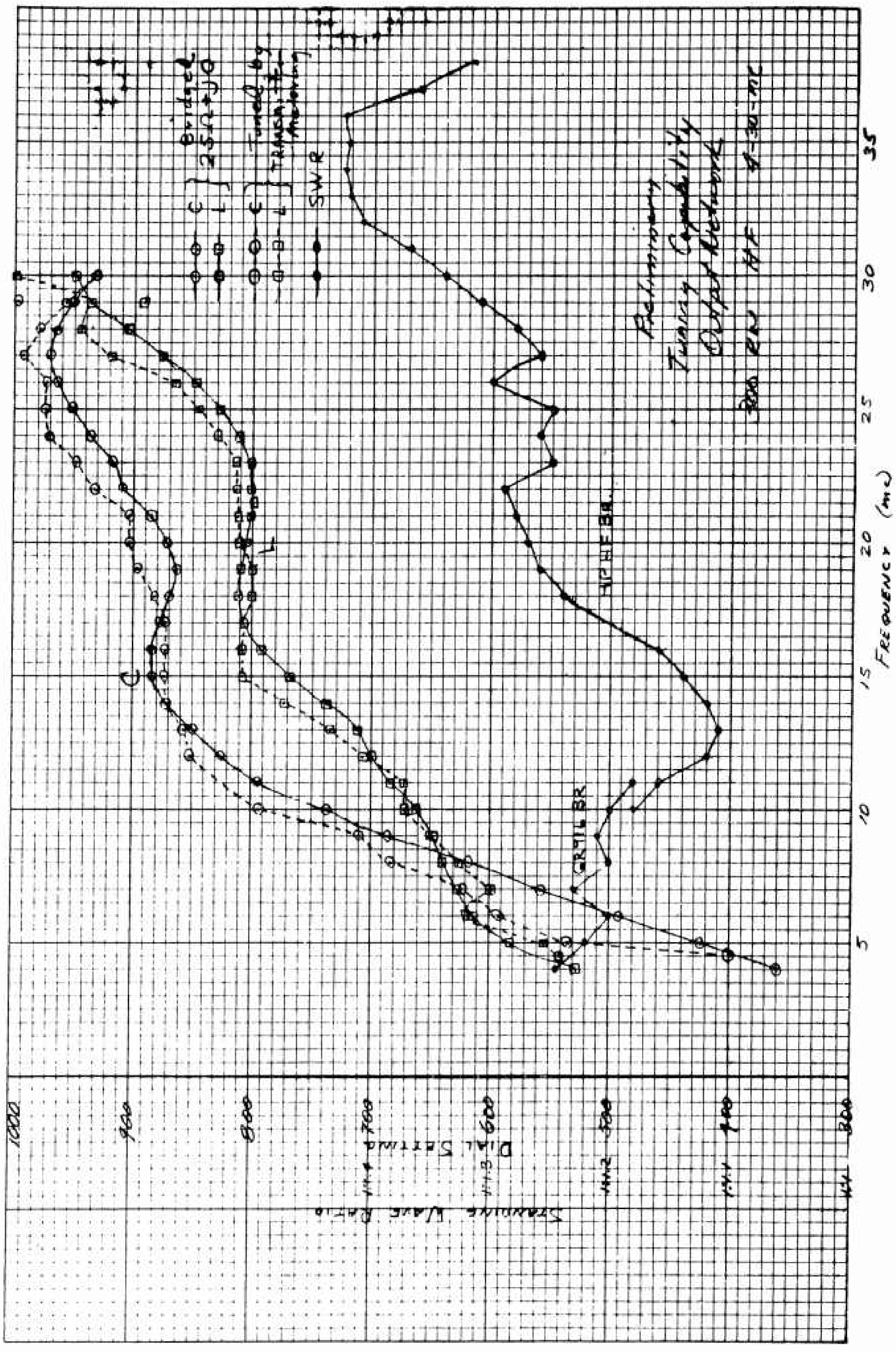
3

...ICATION IN ONE STAGE NEVER EXCEEDS 3.

...F I.P.A. GRID CURRENT. SET FOR MAXIMUM CURRENT ABOVE 28 MEGACYCLES.

...T AS NOTED.

PRELIMINARY TUNING CAPABILITY, 300-Kw HF OUTPUT NETWORK



PROCEDURE FOR MEASURING HARMONIC OUTPUT OF THE 300-Kw HF POWER AMPLIFIER

I. GENERAL

The output of the 300-Kw HF power amplifier is sampled in the coaxial line between the tuning network and the Corning glass resistor load by a small loop. The output from the loop is measured by an Empire NF-105 Field Strength and noise meter. Actually, two NF-105's are used. One covers the 0.15 to 30.0 mc range, and the other tunes from 20 to 200 mcs. The output variation of the loop - NF-105 system for a fixed power level in the coaxial line feeding the load has been measured for the 4 - 100 mc frequency range, and is plotted in the accompanying curve. Thus, when the gain of the NF-105's is set to correspond to the gain curve, the measured fundamental and harmonic signal levels can be corrected for the variations in meter gain and frequency to give an accurate measurement of relative fundamental and harmonic signal strengths.

II. CALIBRATION AND MEASUREMENT PROCEDURE

A. For the case where the fundamental and harmonic frequencies fall within the range of one tuning head.

1. Carefully tune the NF-105 for maximum meter reading at the fundamental frequency.

2. Adjust the IF gain and input attenuator for a combined reading near 100 db. Using this as a reference level, the harmonic levels can then be measured and recorded in db. The method of correcting for the variation of gain with frequency will be outlined in Part III.

   NOTE: It is suggested that the input attenuator on only one of the NF-105 basic units be used with both

tuning heads so that an additional error due to dissimilarities in the two attenuators will not exist. In the set-up for this test, the attenuator in the serial No. 153 unit will be used.

There is one exception to the above statement. In the 20, 40, 60 and 80 db ranges of the input attenuator, 0, 20, 40 and 60 db of attenuation respectively is switched in series with the input lead to the tuning head in use, while the meter gain remains constant at 25 volts full scale. However, the meter gain is increased to 2.5 volts full scale in the 0 db position of the attenuator, and there remains zero db of attenuation in the tuning head input lead. This makes it necessary to switch the attenuator of the serial No. 338 unit to the zero db position when this sensitivity range is desired for the 20 to 200 mc head. The attenuator on No. 153 can be at either 0 or 20 db in this case since there is zero db of rf attenuation at either setting. The operator must be careful to reset the No. 338 attenuator to 20 db when this range or higher attenuation ranges are required.

[illegible]. For the case where the fundamental frequency falls below 20 mc and the 20-200 mc is used to measure some of the harmonics.

[illegible]. The IF gain of the two units must be adjusted so that the

relative gain over the 4 to 100 mc range corresponds to the accompanying gain curve.

2. The impulse generator in the serial No. 338 unit is used as a transfer standard to set the relative gain of the two units to the same value. Measurements with a fixed output power 30 mc cw signal as a voltage standard show that when the No. 338 unit is set to have 2 db more output at 30 mc than the No. 153 unit with the same input (this corresponds to the gain curve), the No. 338 unit has 20 db more output than the No. 153 unit when the impulse generator is used as a signal source. Due to the much greater bandwidth of the 20 - 200 mc tuning head, a proportionally greater amount of impulse generator output power is transmitted through this head than through the 0.15 to 30.0 mc head.

3. Tune in the fundamental signal on the 0.15 to 30.0 mc head. Adjust the attenuator and IF gain for a reference signal between 90 and 100 db with the meter switch in the carrier position. Do not touch the IF gain control after this step.

4. Switch both meters to peak position.

5. Connect the impulse generator to the signal input (attenuator input) terminal and turn impulse operator on.

6. Tune both heads to 30 mc.

7. With the impulse generator attenuator in the 90 db position, adjust the signal input attenuator and the impulse generator output control to a convenient reading

on the serial No. 153 meter (the suggested signal input attenuator setting is 40 db).

8. Connect the attenuator output lead to the 20 - 200 mc head, and set the input attenuator 20 db higher than step 7.

9. Adjust the serial No. 338 IF gain control for a meter reading which is the same as that of part 7.

10. Both NF-105's are now calibrated so they will track with the accompanying gain curve. Return the meter switches to the carrier position, and turn off the impulse generator to prolong the life of the generator contacts.

11. Fundamental and harmonic levels can then be made on the appropriate head, recorded in db, and corrections made using the procedure outlined in Part III.

III. CORRECTIONS FOR GAIN VARIATION WITH FREQUENCY

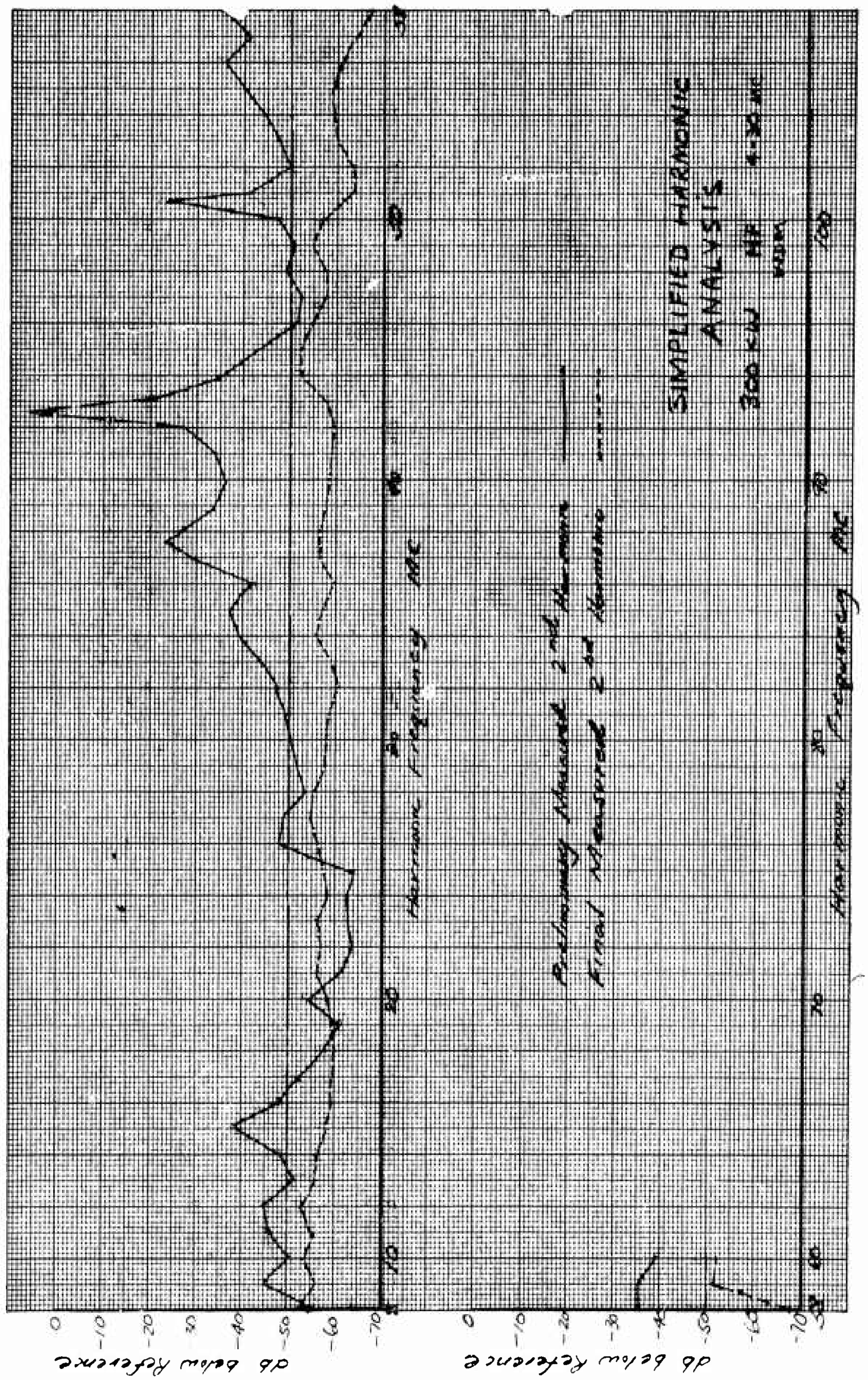
A. From the curve, find the gain figures corresponding to the fundamental and the harmonic frequency.

B. Subtract the fundamental gain from the harmonic gain.

C. Subtract the result of B from the harmonic signal level. This is the corrected, measured level of the harmonic.

D. To level of the harmonic in db below the fundamental level, subtract C from B.

SIMPLIFIED HARMONIC ANALYSIS, 300-Kw HF



FINAL ACCEPTANCE TESTS

SAMPLE SHEETS, HARMONIC DATA

This data includes all meter readings, dial settings and signal-to-noise data at 3 db points.

DATA SHEET

EQUIPMENT	SERIAL NR.	MODEL (e.g. Preproduction)
300 KW HF AMPLIFIER	1	EXPERIMENTAL
MANUFACTURER: CEMC	ORDER NR.: DA-36-039-SC64441	SPECIFICATION NR.: SCL-1517
TYPE OF TEST: HARMONIC MEASUREMENTS – ACCEPTANCE TEST		SPECIFICATION PARAGRAPH

FUNDAMENTAL FREQ (MCS)	FUNDAMENTAL REF. LEVEL (DB)	2nd HARMONIC MEAS. LEVEL (DB)	2nd HARMONIC CORR. LEVEL (DB)	2nd HARMONIC DB BELOW FUND. LEVEL	3rd HARMONIC MEAS. LEVEL (DB)	3rd HARMONIC CORR LEVEL (DB)	3rd HARMONIC DB BELOW FUND. LEVEL	4th HARMONIC MEAS. LEVEL (DB)	4th HARMONIC CORR. LEVEL (DB)	4th HARMONIC DB BELOW FUND LEVEL
			3.5			9.3			12.3	
[illegible]	93.0	53.5	50.0	43.0						
	[illegible]	37.5	34.0	58.6	7.5	-1.8	94.3	21.5	9.2	83.4
			3.4			8.6			12.3	
[illegible]	92.3	[illegible]	[illegible]	41.4						
	93.0	[illegible]	[illegible]	[illegible]	10.0	1.4	91.6	12.5	.2	92.8
/			3.4			8.6			12.2	
[illegible]	92.2	53.3	[illegible]	43.3						
	[illegible]	36.8	33.4	[illegible]	[illegible]	[illegible]	92.6	11.0	-1.2	93.2
			3.2			8.8			12.0	
[illegible]	[illegible]	[illegible]	51.8	[illegible]						
	[illegible]	[illegible]	33.6	58.4	[illegible]	1.2	[illegible]	9.0	-3.0	95.0
			[illegible]			[illegible]			[illegible]	
[illegible]	[illegible]	56.0	[illegible]	38.4						
	[illegible]	[illegible]	[illegible]	57.4	11.5	[illegible]	89.0	12.0	.9	91.1
			2.5			8.8			11.2	
[illegible]	92.0	[illegible]	54.0	38.0						
	[illegible]	[illegible]	[illegible]	[illegible]	11.0	2.2	89.8	12.5	1.3	90.7
			2.4			9.2			10.6	
[illegible]	[illegible]	[illegible]	54.4	36.6						
	[illegible]	[illegible]	[illegible]	[illegible]	13.0	3.8	87.3	[illegible]	1.9	87.2
			2.6			9.4			10.8	
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]						
	91.7	[illegible]	[illegible]	52.3	6.0	-3.4	95.1	[illegible]	1.2	90.5

REMARKS

DATE	PAGE NR.	SIGNATURE	TABLE
[illegible]	[illegible]		

FMSC Form 88 AE
1 Jul 57

(Replaces SCEL-6C Form 391A which is obsolete)

Army-Ft Monmouth, NJ-MON 3020-57

DATA SHEET

EQUIPMENT	SERIAL NR.	MODEL (e.g. Preproduction)
300 KW HF AMPLIFIER		EXPERIMENTAL
MANUFACTURER	**ORDER NR.**	**SPECIFICATION NR.**
CEMC	DA-36-039-SC-64441	SCL-1517
TYPE OF TEST		**SPECIFICATION PARAGRAPH**
300 KW HF AMPLIFIER ACCEPTANCE TEST		

						L NET INPUT		L NET OUTPUT			
FREQ.	INPUT SWR F / R	EG AC	EP AC	IG	IP	PWR	SWR	PWR	SWR	FB AMP SERVO	PWR LOAD
16,515	48/0	68	69	300	33	325	37/4.5	[illegible]	25/2	5900	300
16,343	48/0	67	76	325	33.5	335	39/0	320	26/2	6000	305
16,228	48/2	67	76	320	32	315	38/0	305	25/2	6000	305
16,059	44/0	67	76	320	33	310	38/0	300	25/2	6000	300
15,944	46/1	67	76	300	32.75	320	38/.5	300	25/2	6000	305
15,812	45/0	66	75	300	32.5	310	38/1	300	25/2	6000	300
15,681	48/3	67	76	300	32.5	320	38/0	300	25/2	6100	307
15,606	48/0	68	76	320	32.5	325	28/.5	305	25/2	6100	302
15,472	50/0	69	76	325	33.5	325	39/0	315	25/2	6400	305
15,323	49/5	68	74	320	34	335	38/.5	305	25/2	6100	305
15,175	50/1	70	75	320	33	325	39/.5	310	25/1	6600	300

REMARKS

DATE	PAGE NR.	SIGNATURE	TABLE
4/22/58	7A		

FMSC Form 88 AE 1 Jul 57 (Replaces SCEL-SC Form 301A which is obsolete) Army-Ft Monmouth, NJ-MON 3030-57 SCEL

DATA SHEET

EQUIPMENT	SERIAL NR.	MODEL (e.g. Prepr.)
300 KW HF AMPLIFIER		EXPERIMENTA
MANUFACTURER	ORDER NR.	SPECIFICATION NR.
CEMC	DA-36-039, SC-64441	SCL-1517
TYPE OF TEST		SPECIFICATION PARAGRAPH
300 KW HF AMPLIFIER ACCEPTANCE TEST		

DIAL SETTINGS

FREQ.	GRID TUNE	PLATE TUNE	PLATE LOAD		OUTPUT NETWORK L	OUTPUT NETWORK C	π C	Pwr in Trap	Temp Doss.
16515	852	888	627		768	815	995	—	0
	852	888	627		768	770	750	—	0
16343	849	888	622		767	818	995	—	0
	~~849~~	~~888~~	~~622~~		~~753~~	~~772~~	~~690~~	—	0
	849	888	622		750	780	750	—	0
16228	845	887	622		762	811	995	—	0
	~~"~~	~~"~~	~~"~~		~~751~~	~~756~~	~~660~~	0.15	.1
	"	"	"		750	778	750	—	0
16089	840	882	622		756	819	995	—	0
	"	"	"		748	776	750	—	0
15944	838	880	622		762	813	995	—	0
" "	"	"	"		743	780	750	—	0
15,812	836	878	615		753	807	995	—	0.2
	836	878	615		743	780	750		0.1
15,681	834	879	615		755	807	995	—	0
	"	"	"		740	772	750	—	0
15606	830	877	616		750	810	995	—	0
	"	"	"		732	772	740	—	0
15,472	827	875	616		755	803	995	—	0
	"	"	"		733	770	750	—	0
15,323	824	874	617		752	797	995	—	0
" "	824	874	617		729	769	750	—	0
15175	818	868	617		738	800	995	—	0
	"	"	"		729	767	750	—	0

REMARKS

DATE	PAGE NR.	SIGNATURE	TABLE
4-22-58	7		

FMSC Form 1 Jul 57 88 AE (Replaces SCEL-SC Form 391A which is obsolete) Army-Ft Monmouth, NJ-MON 3020-57

DATA SHEET

EQUIPMENT	SERIAL NR.	MODEL (e.g. Preproduction)
LD-T2		PRODUCTION
MANUFACTURER	**ORDER NR.**	**SPECIFICATION NR.**
WESTERN ELECTRIC	DA-36-039-SC-64441	
TYPE OF TEST		**SPECIFICATION PARAGRAPH**
300 KW HF AMPLIFIER ACCEPTANCE TEST		

FREQ.	HF MOD	AMP 123	AMP 4	AMP 5 GRID	AMP 5 PLATE	AMP 6 GRID	AMP 6 PLATE	OUT COUP	OUT BAL	HF GAIN	RANGE
17331	90	38	45	64	31	50	30	43	40	2	9
17151	90	34	47	64	28	50	25	43	40	4	9
16994	90	32	43	64	20	50	26	43	40	6	9
16835	90	30	42	64	20	50	32	43	40	10	9
16659	90	28	40	64	22	51	18	35	40	6	9
16515	88	56	55	69	54	66	62	48	66	2	8
16343	90	56	53	70	56	66	70	49	66	2	8
16228	88	52	50	70	51	66	72	48	66	4	8
16089	88	52	46	70	56	66	58	49	66	4	8
15944	87	48	46	70	52	66	59	40	66	4	8
15812	87	48	45	70	48	66	59	40	66	6	8
15681	86	48	42	70	51	66	60	30	62	4	8
15606	87	45	37	70	44	66	58	30	62	2	8
15472	86	42	36	70	42	66	58	30	62	2	8
15323	85	40	32	70	42	66	50	29	62	4	8
15175	85	40	33	70	35	66	50	29	62	6	8
15065	84	38	30	70	39	66	56	29	62	6	8
14963	84	35	26	70	37	66	46	20	62	6	8
14852	84	32	26	70	34	66	46	20	62	6	8
14709	84	31	23	70	34	66	46	20	62	8	8
14606	84	30	28	70	32	66	42	20	62	10	8
14507	83	29	22	70	36	66	[illegible]	[illegible]	62	12	8
14404	82	25	25	54	38	50	37	[illegible]	56	7	8
14404	83	26	26	54	28	[illegible]	37	[illegible]	56	[illegible]	8
14312	82	26	23	54	30	50	40	[illegible]	56	[illegible]	8

REMARKS

Changed to Range 8

DATE	PAGE NR.	SIGNATURE	TABLE
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DATA SHEET

EQUIPMENT	SERIAL NR.	MODEL (e.g. Preproduction)
MASTER OSCILLATOR LD-T-2		PRODUCTION
MANUFACTURER: CEMC	ORDER NR.: DA-36-039-SC-64441	SPECIFICATION NR.
TYPE OF TEST: 300 KW HF AMPLIFIER ACCEPTANCE TEST		SPECIFICATION PARAGRAPH

FREQ	MC SET		Ip	OUTPUT IND	ALC PA	ALC ALT		DISTORTION AMP 6	FKT 26	ALT AMP	300KW PA
17331	10	215	.70	.12	175	30	0926	>-46	-40	-33	41/40
17151	9.9	128	.73	.13	175	60	0937	>-45	-40	-36	41/38
16994	9.8	51	.75	.12	170	5	0950	>-45	-41	-34	37/36
16835	9.8	223	.85	.10	170	0	1003	>-44	-42	-37	39/37
16659	9.7	135	.75	.15	170	10	10:17	>-47	-39	-35	38/36
16515	9.6	60	.72	.14	155	0	10:28	>-47	-45	-35	35/35
16343	9.5	225	.75	.12	165	20	11:00	>-45	-43	-37	38/36
16228	9.5	165	.80	.11	160	15	11:45	>-45	-41	-37	37/35
16089	9.4	92	.80	.10	160	30	1213	>-45	-36	-39	36/36
15944	9.3	14	.75	.12	160	25	12:30	>-46	-38	-38	40/36
15812	9.3	192	.79	.11	175	25	13:17	>-45	-37	-37	40/37
15681	9.2	121	.65	.18	165	10	13:46	>-49	-40	-39	44/38
15606	9.2	80	.69	.17	168	10	14:13	>-48	-40	-36	42/37
15472	9.1	5	.69	.16	165	10	14:22	>-48	-38	-38	39/36
15323	9.	173	.70	.12	170	30	14:35	>-47	-38	-45	44/38
15175	8.9	96	.72	.13	165	3	14:46	>-46	-35	-36	41/38
15065	8.9	28	.74	.12	160	5	14:56	>-46	-39	-39	42/38
14963	8.8	220	.73	.14	160	3	15.05	>-47	-39	-39	42/38
14852	8.8	158	.72	.14	160	10	15:14	>-47	-38	-40	40/38
14709	8.7	77	.75	.12	170	5	15:22	>-46	-39	-41	46/39
14606	8.7	18	.75	.11	160	0	1544	>-46	-37	-40	49/38
14[illegible]27	8.6	231	.79	.11	170	5	1553	-45	-36	-39	43/37
1[illegible]04	8.6	153	.70	.19	165	10	1410	-51	-40	-40	41/37
144[illegible]	8.6	[illegible]	.75	.14	160	15	1950	>-51	-48	-48	44/36
14312	8.5	103	.72	.12	160	25	2003	>-46	-40	41	43/38

REMARKS

DATE	PAGE NR.	SIGNATURE	TABLE
4-22-58	4	[illegible]	

DATA SHEET

EQUIPMENT	SERIAL NR.	MODEL (e.g. Preproduction)
FRT-26 AND ALT. AMPLIFIER	1	EXPERIMENTAL
MANUFACTURER	ORDER NR.	SPECIFICATION NR.
CEMC	DA-36-039-SC64441	SCL-1517
TYPE OF TEST		SPECIFICATION PARAGRAPH
300 KW HF AMPLIFIER ACCEPTANCE TEST		

	FRT 26						ALT. AMPLIFIER				
FREQ	IG L	IG R	IP	IL L	IL R	EG AC	EP AC	IG	IP	PO AVE	SWR F/R
17.331	0	0	1.5	2	2.4	15	56	0	2.9	8,5	9/0
17.151	0	0	1.5	2.1	2.4	16	58	0	2.9	8.5	10/0
16994	0	0	1.6	2	2,3	15	50	0	3	8	9/0
16,835	0	0	1,5	1,9	2,3	15	47	0	3	7,5	9/0
16,639	0	0	1.6	2	2.5	16	51	0	3,2	9,5	10.5/0
16,515	0	0	1,6	2	2,3	14	46	0	3	8	9/0
16,343	0	0	1.5	1,9	2,2	15	53	0	3	8	9/0
16228	0	0	1,6	1,9	2,2	15	51	0	3	8,5	8,5/0
16089	0	0	1,5	1	1	15	54	0	3	8,5	9/0
15944	0	0	1,5	1	1	15	54	0	2,7	8,5	9/0
15,812	0	0	1,5	1	1	15	54	0	2,9	7,5	8/0
15,681	0	0	1,5	,9	,9	15	54	0	2,9	7,5	8,5/0
15.606	0	0	1,5	,8	,8	15	54	0	3,0	8,5	10/0
15,472	0	0	1,6	,8	,8	15	54	0	3,0	8,5	9,5/0
15,323	0	0	1,6	,8	,8	15,5	59	0	2,9	8	9,5/0
15,175	0	0	1,5	,6	,6	15	50	0	3	8,5	9/0
15,065	0	0	1,6	,5	,5	15	53	0	2,9	8,0	9/0
14,963	0	0	1,6	,5	,5	15	52	0	3,0	8,0	9/0
14,852	0	0	1,6	,5	,5	15	53	0	3,0	8,0	9/0
14,709	0	0	1,5	,4	,4	15	53	0	3,0	8,5	9,5/0
14,606	0	0	1,5	,4	,4	14	50	0	2,9	7	8/0
14,507	0	0	1,6	,4	,4	15	53	0	2,9	7	8/0
14,404	0	0	1,6	,4	,4	15,5	54	0	3,0	9	10,5/0
14,312	0	0	1,5	,4	,4	15	58	0	2,7	7,5	8,5/0
14,241	0	0	1,7	,3	,3	15	52	0	2,95	7,5	8,5/0

REMARKS

DATE	PAGE NR.	SIGNATURE	TABLE
4/22/58	4		

DATA SHEET

EQUIPMENT	SERIAL NR.	MODEL (e.g. Preproduction)
FRT 26 AND ALT. AMPLIFIER		EXPERIMENTAL
MANUFACTURER	**ORDER NR.**	**SPECIFICATION NR.**
CEMC	DA 36 039-SC-64441	SCL-1517
TYPE OF TEST		**SPECIFICATION PARAGRAPH**
300 KW HF AMPLIFIER ACCEPTANCE TEST		

FRT 26 DIAL SETTING						ALT. AMPLIFIER DIAL SETTING				
FREQ.	DRIVER PLATE	P.A. PLATE	P.A. LOAD	ANT TUNE	ANT GND SWITCH		GRID TUNE	PLATE TUNE	PLATE LOAD	
17.331	785	829	721	764	OFF		750	618	437	
17.151	793	826	721	761	"		750	615	437	
16.994	791	822	721	759	"		750	612	454	
16.835	778	818	721	765	"		750	612	454	
16.659	777	818	721	752	"		740	608	454	
16.515	784	816	721	754	"		740	606	454	
16,343	780	809	721	750	"		740	602	416	
16,228	780	807	721	751	"		740	601	416	
16.089	778	805	976	900	GND.		775	599	400	
15,944	777	801	975	902	"		775	598	400	
15.812	775	800	975	895	"		775	596	400	
15.681	762	800	975	893	"		775	592	400	
15606	771	796	975	887	"		775	592	400	
15,472	759	795	974	885	"		775	588	400	
15,323	755	790	975	880	"		775	586	400	
15,175	764	789	975	873	"		775	582	400	
15,065	760	788	975	874	"		775	582	400	
14,963	762	788	968	869	"		775	580	400	
14.852	758	786	968	866	"		775	577	400	
14,709	757	783	968	861	"		775	575	400	
14.606	756	785	968	859	"		775	572	400	
14.507	746	785	968	855	"		775	568	400	
14,404	757	779	968	850	"		775	568	368	
14.312	740	781	967	846	"		770	568	368	
14,241	749	778	960	844	"		768	564	368	

REMARKS

DATE	PAGE NR.	SIGNATURE	TABLE
4/22/58	4		

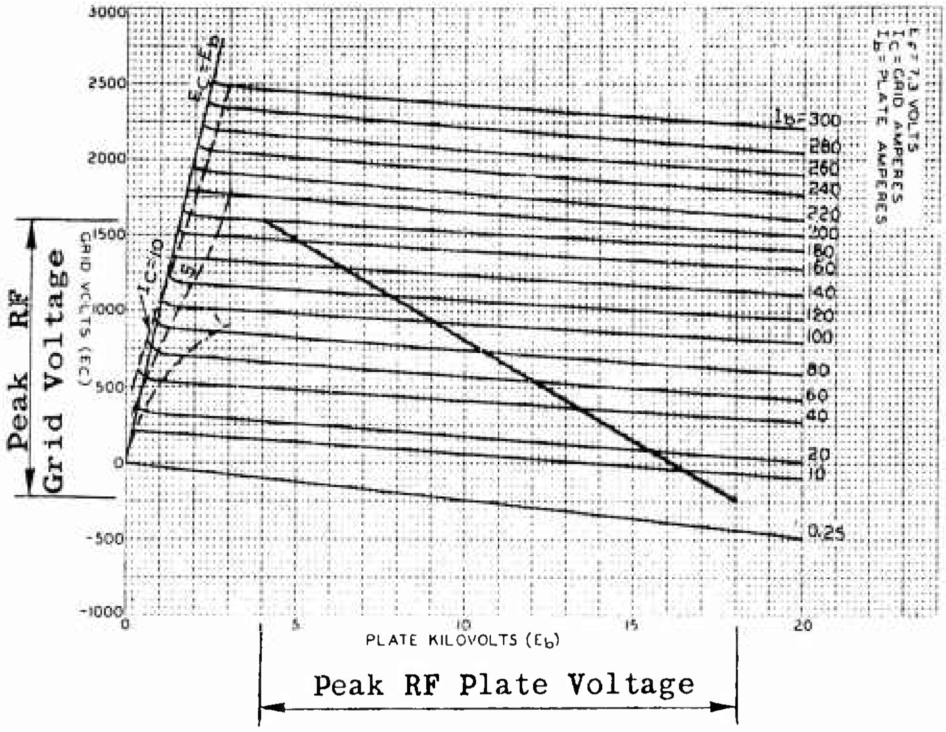
FMSC Form 88 AE 1 Jul 57 (Replaces SCEL-SC Form 391A which is obsolete) Army-Ft Monmouth, NJ-MON 3020-57

REFERENCE DATA ON LOOP BALUNS

A Signal Corps Contract No. DA-36-039 SC-64486 to Developmental Engineering Corporation on the subject of Reliable High-Frequency Communications, Report No. 3-P-5, 5th Progress Report, Period Covered 1 April 1956 through 31 July 1956, is referenced as design criteria for manufacturing CEMC's loop balun.

LOAD LINE CALCULATIONS

RCA 6949
(Graphical Analysis)



	600 kw Peak (for Ref. Only)	300 kw Ave. (2 Tone SSB)
DC Plate Voltage E_b	18 kv	18 kv
DC Bias Voltage E_c	-230 v	-230 v
Peak RF Plate Voltage E_{pmax}	14 kv	14 kv
Peak RF Plate Current i_{pmax}	160 A	160 A
Peak Fundamental RF Plate Current I_{pmax}	85.8 A	85.8 A
DC Plate Current I_b	52.5 A	33.3 A (meter reading)
Plate Resistance R_p	165 ohm	165 ohm
Plate Power Output P_o	600 kw	300 kw (meter reading)
Plate Power Input P_i	945 kw	600 kw
Plate Efficiency N	63.5%	50%
Plate Dissipation P_p	345 kw	300 kw (meter reading)
Grid Current I_c	472 MA	300 MA (meter reading)
Peak RF Grid Current igmax	3 A	3 A
Peak RF Grid Voltage E_{gmax}	1830 V	1830 V
Grid Power P_g	860 w	430 w
Grid Resistance R_g	1950 ohms	1950 ohms
Swamping Resistance R	50 ohms(nom.)	50 ohms(nominal)
Driving Power	30 kw(nominal)	15 kw(nominal)

INPUT LOAD DATA VERIFYING CHANGE FROM 50 OHM SWAMPING RESISTOR TO 75 OHM SWAMPING RESISTOR.

Bridge measurements were made on input circuit of the 300 KW HF amplifier when tuned to 16 Mc. The input impedance measured pure resistance at a value of 210-ohms. At either side of resonance, the impedance value would fall off sharply. The input transmission line was disconnected and bridge measurements made looking toward the 50-ohm swamping resistor from the drawer terminal. The input impedance measured 39-j18. This series impedance connects directly to the parallel equivalent impedance of 47-j103. Theoretically, when the drawer and swamping resistor circuits are parallelled, the net series impedance becomes 33.5-j12.5. Under these conditions, this is the load that the alternate amplifier is working into when the grid is tuned to resonance. By off tuning the grid circuit, the impedance can be made 38.3+j0.

Conclusion

1. Swamping resistor load circuit does not affect the drawer voltage transformation ratio.
2. If the swamping resistor load was good, the input impedance would be correct.
3. Two of the Corning glass resistors, 300-ohms each, would have to be removed leaving four of the 300-ohm resistors in the circuit for a total of 75-ohms.

PARASITIC SUPPRESSION

While operating on a frequency of 8 mc, a parasitic oscillation existed on 72 mc. To squelch the 72 mc energy, three devices were employed.

1. Unused turns shorting device for grid inductor.
2. Series resistors with the grid connections of the tubes.
3. De-Q-ing of return path for Jennings vacuum capacitors used from grid to ground for input padding.

Shorting of unused portion of grid inductors -

Shorting devices were installed to de-Q back turn resonances of the grid inductors at 1/2 turn, 1 turn and 1-1/2 turns from the main current carrying contact.

Grid connector de-Q-ing -

1 ohm of a combination of 2 watt resistors was inserted in the grid connector to the power amplifier tube. This value seemed adequate to de-Q the parasitic circuit. The problem became - how to get 1 ohm of resistance in the circuit of 72 mc with no appreciable resistance at 30 mc and lower frequencies.

Experiment

One of the grid connector leads was removed from the transmitting equipment and a No. 8 bare copper wire was soldered to the lead on a 3/8" pitch spread for 3" of the lead. The copper wire was coated with a powdered iron resistive material bonded with talc and DC 2105, flush with the copper wire.

Freq. (mc)	Bridge Dial Z (ohms)	Bridge Dial θ (Degrees)	Corrected θ (Degrees)	R+jX (ohms)
100	26.0	89	89.0	.44 +j25.9
90	22.5	99	89	.39 +j22.4
80	19.5	111	88	.4 +j19.4
70	16.5	128	89.5	.165+j16.4
60	14.0	148	88.8	.29 +j13.9

The powdered iron material was increased from 3" to 6" of No. 8 wire on 3/8" pitch. This powdered iron was bonded without talc.

Freq. (mc)	Bridge Dial Z (ohms)	Bridge Dial θ (Degrees)	Corrected θ (Degrees)	R+jX (ohms)
100	26.5	88	88.0	.92+j26.4
90	23.0	98	88.2	.72+j22.9
80	20.0	110	88.0	.7 +j19.9
70	17.0	125	87.5	.74+j16.9
60	14.7	145	87.0	.77+j14.5
53	12.7	164	87.0	.67+j12.5

Highest obtainable resistance value

Both grid connecting leads covered with above amount of powdered iron and power tests of the transmitter indicated no parasitic oscillation.

De-Q-ing of return path for padding capacitors

Further power tests under driven conditions indicated that 72 mc parasitic oscillation was still present. Voltage arcs around "HOT" end of Jennings capacitors indicated that these devices were in the oscillatory circuit.

Experiment One

One of the Jennings capacitors was placed in a configuration simulating its actual position in the equipment. A slug of powdered iron bonded with "Q" dope, approximately 1/4 inch thick, 1 inch wide and 2 inches long, was placed in series with the "HOT" lead of the capacitor. The following data were recorded:

Freq. (mc)	Bridge Dial Z (ohms)	Bridge Dial θ (Degrees)	Corrected θ (Degrees)	R+jX (ohms)
100	4.1	79	79.0	.78+j4
90	2.0	40	36.0	
80	3.5	98	-78.5	.7 -j3.45
70	7.7	-121	-84.6	.75-j7.6
60	12.5	-145	-87.0	.65-j12.3
53	16.5	-165	-87.5	.72-j16.3

The powdered iron slug was replaced with copper plate and the following data were recorded:

Freq. (mc)	Bridge Dial Z (ohms)	Bridge Dial θ (Degrees)	Corrected θ (Degrees)	R+jX (ohms)
100	3.7	88	88.0	.129
90	2.0	88	88.0	
80	3.2	-107	-86.5	.195
70	7.2	-125	-87.5	.314
60	11.8	-148	-88.8	.242
53	15.5	-168	-89.1	.155

The powdered iron increased the resistance at 72 mc.

<u>Experiment Two</u>

Five dovetail 1/4" grooves were cut in the end of the capacitor mounting arrangements of the transmitter. The grooves were filled with powdered iron bonded with "Q" dope.

Freq. (mc)	Bridge Dial Z (ohms)	Bridge Dial θ (Degrees)	Corrected θ (Degrees)	R+jX (Ohms)
100	14.0	87	87.0	.73 +j13.9
90	9.8	96	86.3	.633+j9.7
80	5.4	105	84.0	.565+j5.3
70	2.0	80	56.0	
60	4.3	-138	82.8	.54 +j4.2
53	8.2	-162	85.8	.6 +j8.1

The powdered iron material was removed from the grooves and the following data were recorded:

Freq. (mc)	Bridge Dial Z (ohms)	Bridge Dial θ (Degrees)	Corrected θ (Degrees)	R≠jX (Ohms)
100	13.5	89	89.0	.23 ≠j13.4
90	9.0	99	89.2	.13 ≠j8.9
80	4.8	109	87.2	.24 ≠j4.7
70	2.0	0	0.0	
60	5.0	-142	85.2	.4 -j4.9
53	9.0	-167	88.5	.236-j8.9

Conclusion

It is noted that the resistance measurements are increased for the 70 mc and higher frequencies.

FINAL CONCLUSION

The power tests proved that the three methods of solving the 72 mc parasitic oscillation are required for successful operation of the transmitting equipment.

DATA SHEET

EQUIPMENT	SERIAL NR.	MODEL (e.g. Preproduction)
300 Kw HF Dummy Load		Experimental
MANUFACTURER: CEMC	ORDER NR.: DA-36-039 SC 64441	SPECIFICATION NR.: SCL 1517
TYPE OF TEST: Vswr Measurements thru 44 feet of 6-1/8 line		SPECIFICATION PARAGRAPH

	Freq. mc	Z ohms	θ degrees	θ_C Corr. Deg.	R ohms	X ohms	Norm R ohms	Norm X ohms	VSWR Ratio
	10.	55	85	8.5	54.2	8.12	1.08	.163	1.18
	11.	57	35	3.85	57	3.83	1.14	.077	1.16
	12.	56	-10	-1.2	56	-1.16	1.12	-.023	1.12
	13.	53	-37.5	-4.88	53	-4.5	1.06	-.090	1.11
	14.	49	-45	-6.3	48.7	-5.37	.97	-.108	1.12
	15.	45.5	-35	-5.25	45.3	-4.17	.91	-.083	1.14
	16.	43	-10	-1.6	43	-1.2	.86	-.023	1.16
	17.	42	23	3.91	42	2.86	.84	-.057	1.2
	18.	43	50	9.	42.4	6.73	.85	.135	1.24
	19.	47	67.5	12.8	45.8	10.4	.915	.208	1.26
	20.	52	67.5	13.5	50.6	12.5	1.01	.25	1.27
	21.	57	55	11.6	55.9	11.7	1.12	.234	1.28
	22.	60	42.5	9.35	59.2	9.75	1.18	.195	1.29
	23.	62	12.5	2.88	62	3.12	1.24	.062	1.25
	24.	62	-17.	-4.08	62	-4.41	1.24	-.085	1.26
	25.	58	-38	-9.51	57.2	-9.58	1.14	-.192	1.25
	26.	52	-49	-12.7	50.8	-11.4	1.02	-.248	1.3
	27.	45.5	-47.5	-12.3	44.5	- 9.69	.89	-.191	1.26
	28.	41	-30	- 8.4	40.6	- 5.99	.811	-.12	1.28
	29.	38.2	- 6	- 1.74	38.2	- 1.16	.765	.765	1.31
	30.	38	21	6.3	38	4.17	.760	.083	1.34
	31.	40.7	44	13.6	39.6	9.57	.79	.192	1.38
	32.	46	57	18.3	43.7	14.6	.875	.29	1.4
	33.	53	59	19.5	50	17.7	1.0	.355	1.42
	34.	60.5	48	16.3	58.2	17	1.16	.34	1.41

REMARKS

DATE	PAGE NR.	SIGNATURE	TABLE
1-24-58			

DATA SHEET

EQUIPMENT	SERIAL NR.	MODEL (e.g. Preproduction)
300 Kw HF Dummy Load		Experimental
MANUFACTURER	**ORDER NR.**	**SPECIFICATION NR.**
CEMC	DA-36-039 SC 64441	SCL 1517
TYPE OF TEST		**SPECIFICATION PARAGRAPH**
Vswr Measurements thru 44 feet of 6-1/8 line		

	mc	Z ohms	θ deg.	θ_C Corr. deg.	R ohms	X ohms	Norm R ohms	Norm X ohms	VSWR Ratio
	35.	67	29	10.1	66	11.7	1.32	.234	1.41
	36.	70	3.5	1 26	70	1.54	1.4	.031	1.43
	37.	66	-18	- 6.66	66	-7.66	1.32	-.153	1.36
	38.	59	-32	-12.1	55.8	-12.6	1.15	-.251	1.32
	39.	52	-36	-14	50.5	-12.6	1.01	-.251	1.29
	40.	45	-28	-11.2	44.1	- 8.74	.885	-.175	1.25
	41.	42	-13	- 5.33	42	- 3.9	.84	-.078	1.2

REMARKS

DATE	PAGE NR.	SIGNATURE	TABLE
1-24-58			

USE OF ETHYLENE GLYCOL COOLANT

Corning Glass Dummy Load

The use of a 60-40 ethylene glycol solution as a coolant in the Corning glass ethylene glycol film resistors has been approved as long as the solution does not reach the breakdown temperature. Boiling of the coolant on the film surface must be prevented at all times.

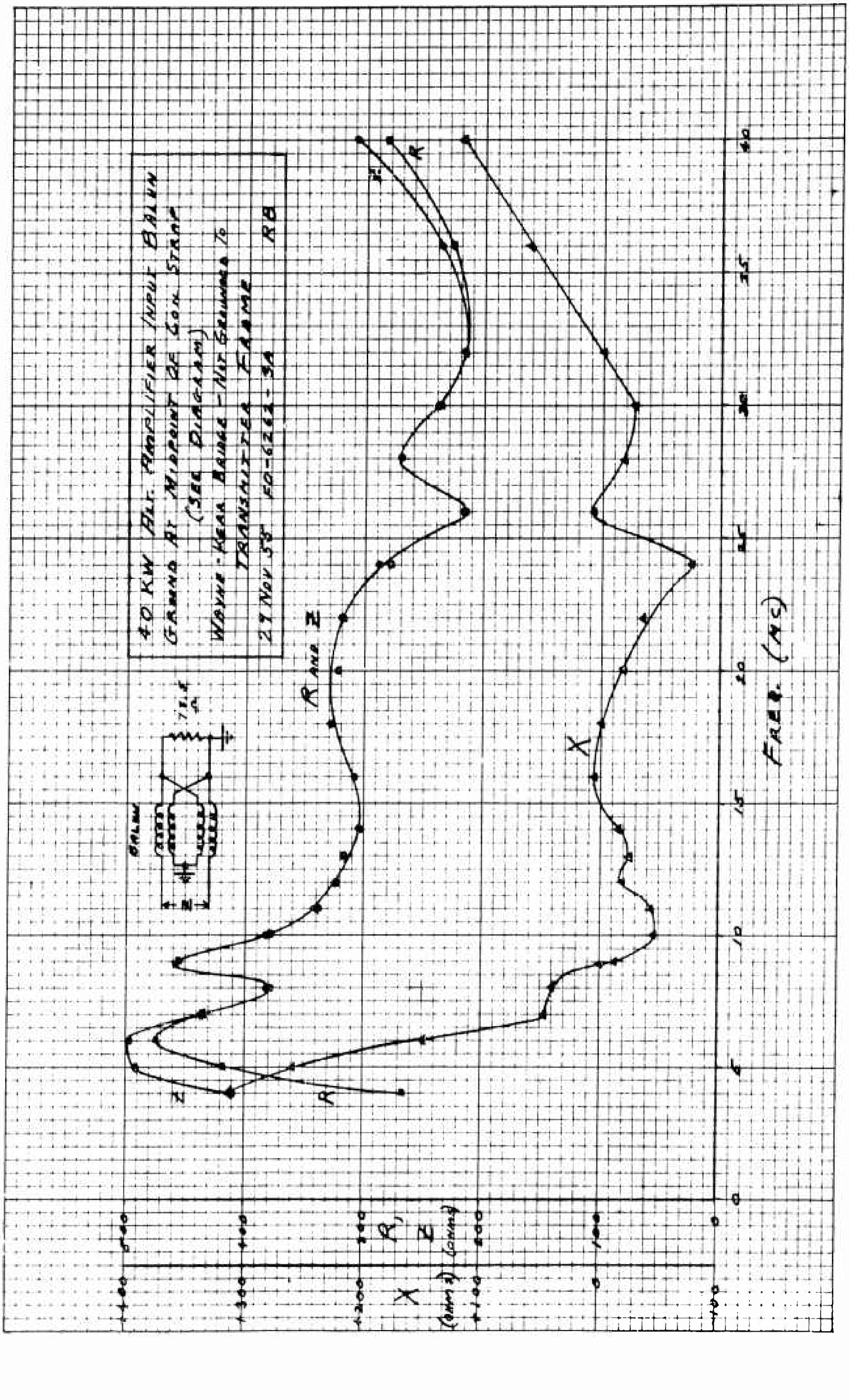
RCA 6949 Tube

Ratings for the use of a 60-40 ethylene glycol-water mixture as a coolant for this application are as follows:

The recommended plate coolant flow for up to 330 kilowatts plate dissipation is 95 gallons per minute with a minimum flow rate of 90 gallons per minute. The maximum pressure drop through the tube at a flow rate of 95 gallons per minute will be 75 pounds per square inch. The minimum coolant pumping temperature is $0^{\circ}F$ ($-18^{\circ}C$).

The recommended beam former coolant flow is 11 gallons per minute with a minimum flow rate of 9.5 gallons per minute. The maximum pressure drop at a flow rate of 11 gpm is 22 pounds per square inch. The recommended minimum coolant flow to the grid-terminal connector is 1.5 gallons per minute. The maximum gauge pressures on the internal coolant courses are the same as quoted for water in the 6949 bulletin.

40-Kw ALTERNAT AMPLIFIER INPUT BALUN



BEFORE ACCOMPLISHING REFER TO GENERAL INSTRUCTIONS AND TO INSTRUCTIONS TO CONTRACTOR FOR FILLING OUT SCEL-SC FORM 516 APPEARING ON REVERSE SIDE

SUMMARY OF ELECTRON DEVICE OPE[...]
SIGNAL CORPS ENGINEERING [...]
RECEIVING AND TRANSMI[...]

(1) CONTRACTOR	ADDRESS	(2) EQUIPMENT NOMENCLATURE & SERVICE USE	(3) SECURITY CLASSIF[...]
Continental Electronics Mfg. Co	[illegible] Dallas, Texas	[illegible] 33 (XC-1)	[illegible]

(4) CONTRACT & ORDER NUMBER	(5) CONTRACT DATE	(6) QUANTITY OF EQUIP ON CONTRACT	(7) COMMERCIAL NOMENCLATURE	(8) CIRCUIT AND/OR SCHEMATIC DIAGRAM NUMBER
DA-36-039 SC-64441	[illegible]	One	CEMC Type 621	—

(9) TOTAL NO OF TUBES PER EQUIPMENT (2)	(10) TOTAL NO OF TUBE TYPES PER EQUIP (2)	(11) EQUIPMENT SUPPLY VOLTAGE MINIMUM	NOMINAL	MAXIMUM	(12) EQUIPMENT OPERATING CYCLE MINIMUM ON
55	26	374VAC	440VAC	503VAC	Continuous

NOTE Electrode voltages measured at maximum supply voltage unless stated otherwise

APPLICABLE RECEIVING AND TRANSMITTING TUBE TYPES

(20) Tube type	(21) Tube function	(22) Socket number	(23) Mtg position of tube	(24) Section	(25) Filament volts min	(26) Filament volts nom	(27) Filament volts max	(28) Plate supply volts	(29) Plate to cathode volts	(30) Plate current mA	(31) Cathode fixed bias volts K-Gnd	(32) Bias resistor ohms	(33) Cathode to heater volts AC	(34) Cathode to heater volts DC	(35) Signal grid fixed bias volts G-K	(36) Grid leak ohms	(37) Signal grid current mA	(38) Screen grid supply volts	(39) Screen to cathode volts	(40) Screen grid current mA	(41) Oscillator grid resistor ohms	(42) Grid current mA min	(43) Grid current mA max	(44)	(45) Duty cycle
6949	350-KW Power Amplifier	XV501	Vert.		[illegible]	7.3	7.8	15KV	15KV	[illegible]A	—	—	—	—	[illegible]	[illegible]	500							[illegible]	
ML6427	40-KW Power Amplifier	XV2201	Vert.			8.0	—	9KV	9KV	4.5A	—	—	—	—	[illegible]	0	[illegible]							[illegible]	
CH-1096	Thyratron HV Shorting Device	XV2508	Vert.	—	6.0	6.3	6.6	18KV	8KV	11A	—	—	—	—	0	[illegible] Effective	—	—	—	—	—	—		[illegible]	
6130	Thyratron Driver	XV2510	Horiz.	—	5.61	6.3	6.6	2.12KV	2.12KV	14.1	—	150	—	—	0	670 Effective	—	—	—	—	—	—		[illegible]	
2D21	Input Thyratron	XV2511	Horiz.	—	5.7	6.3	6.9	350	350	350	—	1000	—	—	0	220K	—	—	—	—	—	—		[illegible]	
12AX7	AC Amplifier	XV3401	Horiz.	Operated Identical	—	6.3	—	90	83.5	0.5	0.5	1200	6.3	0.5	0	470K	0	—	—	—	—	—	—	Cont.	
12AX7	DC Amplifier	XV3402	Horiz.	Operated Identical	—	6.3	—	90	83.5	0.5	0.5	1200	6.3	0.5	0	470K	0	—	—	—	—	—	—	Cont.	
6AU6WA	First Amplifier	XV3501	Horiz.	—	—	6.3	—	230	155	1.0	0.680	680	6.3	230	0	47K	0	230	100	0.4	—	—	—	Cont.	
6SN7	Second Amplifier	XV3502	Horiz.	Paralleled	—	6.3	—	230	126	2.2	3.3	1500	6.3	230	0	470K	0	—	—	—	—	—	—	Cont.	
6336	Mod. 1 and Mod. 2	XV3503 and XV3504	Horiz.	Paralleled		6.3	6.9	230	196	210	34	162.5 Effective	6.3	230	0	220K	0	—	—	—	—	—	—	Cont.	—
2D21	Thyratron	XV3601	Horiz.	—	5.7	6.3	6.9	150 AC	136.4 AC		13.6 AC	1000	0	0	7	100K	0	0	0	—	—	—	—	Cont.	—
6BH6	Load Control Probe	XV3901	Horiz.	—	—	6.3	—	150		0.5	3.75	7.5K	0	0	Variable	220K	0	0	0	2.0	—	—	—	Cont.	—
6AL5	Voltmeter Probe Rectifier	XV4001	Horiz.	one section only	—	6.3	—	11 AC		0.25	14	56K	6.3	14	—	—	—	—	—	—	—	—	—	Cont.	—
12AX7	Amplifier	XV4401	Vert.	Operated Identical	—	6.3	—	216	106	0.5	108	6.4K Effective	6.3	108	0	470K	0	—	—	—	—		—	Cont.	—
2D21	Control Thyratron	XV4403 and XV4404	Vert.	—	5.7	6.3	6.9	300 AC	300 AC			—	—	—	7.0	56K	0	—	—	—	—	—	—	Cont.	
2D21	SWR Protecting and Arc Protecting	XV4601 and XV4602	Vert.	—	5.7	6.3	6.9	117	117		0	500	6.3	0	7.0	100K	0	—	—	—	—	—	—	Cont.	—
6AL5/5726	Probe Rectifier	XV5401	Horiz.	—		6.3		[illegible] AC	20	0.5	0	27.2K Effective	6.3	22		—	—	—	—	—	—	—		Cont.	
6AL5/5726	Probe Rectifier	XV5501	Horiz.	—		6.3		[illegible] AC	20	0.5	0	27.2K Effective	6.3	22			—			—				Cont.	

1

MARY OF ELECTRON DEVICE OPERATING CONDITIONS
SIGNAL CORPS ENGINEERING LABORATORIES

ECEIVING AND TRANSMITTING TYPES

SHEET NO 1 OF 1 SHEETS
REVISION NO —
DATE 30 [illegible] 1961

	(3) SECURITY CLASSIFICATION	TO BE FILLED IN BY SCEL ONLY						
-1)	Unclassified							
CIRCUIT AND/OR SCHEMATIC DIAGRAM NUMBER		(13) VIBRATION (DESIGN SPEC) FREQUENCY (CPS)	ACCELERATION (G'S)	(14) SHOCK (DESIGN SPEC) DURATION (MSEC)	ACCELERATION (G'S)	(15) MAX OPER TEMP (DESIGN SPEC) (°C)	(16) MIN OPER TEMP (DESIGN SPEC) (°C)	
(12) EQUIPMENT OPERATING CYCLE MINIMUM ON: Continuous	MINIMUM OFF	(17) EQUIPMENT MOUNTING		(18) MAX OPER ALTITUDE (FT)		(19) DATE TUBE COMPLEMENT FROZEN		

ING AND TRANSMITTING TUBE TYPES — FOR SCEL USE ONLY

SCREEN GRID			OSCILLATOR GRID			NORMAL OPERATION									ACCELEROMETER MEASUREMENTS		
(38) SUPPLY VOLTS	(39) SCREEN TO CATHODE VOLTS	(40) CURRENT mA	(41) GRID RESISTOR OHMS	(42) GRID CURRENT mA MIN	(43) GRID CURRENT mA MAX	(44) CW OR ICW	(45) DUTY CYCLE	(46) FREQ RANGE OF OPERATION	(47) AMP-LIFIER CLASS	(48) POLARITY AND MAIN MODE OF SIGNAL LEVEL INPUT VOLTS	(49) SEAL TEMP °C	(50) MAX AVER PLATE DISSIPATION WATTS	(51) CATHODE WARM UP TIME	(52) REMARKS	(53) FREQUENCY RANGE	(54) PEAK TO PEAK AMPLITUDE RANGE	(55) ACCELERATION RANGE
						B		4 30mc	B	Positive [illegible]V	<155°C	330W	1 min.	Data shown for SSB operation			
						B		4 30mc	B	Positive 600v	<165°C	201W	—	Data shown for SSB operation			
		—	—	—		[illegible]		DC	—	Positive 1500V	—	0	15min.	Crowbar			
—	—	—	—	—		[illegible]		DC		Positive 176V	—	0	2min.	Crowbar driver			
—	—	—	—	—	—	[illegible]		DC	—	Neg. Cathode [illegible]	—	0	—	Trigger Amp.			
—	—	—	—	—	—	Cont.		60c/s	A_1	Positive 0.5V	—	0.014	—				
—	—	—	—	—	—	Cont.		DC	A_1	Positive 0.5V	—	0.014	—				
230	100	0.4	—	—	—	Cont.		Audio	A_1	Positive 0.68V	—	0.155	—				
—	—	—	—		—	Cont.		Audio	A_1	Positive 3.3V	—	0.277					
—	—	—			—	Cont.	—	Audio	A_1	Positive 34V		20.5/plate					
0	0	—	—		—	Cont.	—	Relay	—	Positive 7V	—	—	—				
0	0	2.0	—	—	—	Cont.		Rect. and DC Amp.	A_1	Positive 3.5V	—		—				
—	—	—	—	—	—	Cont.	—	Rect.	—	———	—	—	—	VTVM			
—	—	—	—		—	Cont.	—	Audio	A_1	Positive 0.5V	—	.053	—				
—	—	—	—	—	—	Cont.		Switching	—	Positive 7V	—	—	—				
			—	—	—	Cont.	—	Switching		Positive 7V	—	—	—				
	—		—			Cont.		———	—	———	—	—	—	Voltage Samples			
		—				Cont.		———	—	———	—		—	Voltage Samples			

2

(SEE REVERSE SIDE)

NOTE Electrode voltages measured at maximum supply voltage unless stated otherwise

REGULATOR AND POWER RECTIFIER TUBE TYPES

(56) TUBE TYPE	(57) TUBE FUNCTION	(58) SOCKET NUMBER	(59) MTG POSITION OF TUBE	(60) SECTION	FILAMENT (61) VOLTS MIN	FILAMENT (62) VOLTS NOM	FILAMENT (63) VOLTS MAX	CATHODE (64) CATHODE TO HEATER VOLTS DC	CATHODE (65) CATHODE TO HEATER VOLTS DC	VOLTAGE REGULATORS (66) TUBE SUPPLY VOLTAGE MIN	VOLTAGE REGULATORS (67) CURRENT mA MAX	VOLTAGE REGULATORS (68) CURRENT mA MIN	VOLTAGE REGULATORS (69) SURGE CURRENT mA	CURRENT REGULATORS (70) FILAMENT CURRENT mA MIN	CURRENT REGULATORS (71) FILAMENT CURRENT mA MAX	CURRENT REGULATORS (72) SURGE CURRENT mA	RECTIFIERS (73) INPUT VOLTS PLATE TO CENTER TAP VOLTS RMS	RECTIFIERS (74) FREQ OF INPUT VOLTAGE CPS	RECTIFIERS (75) EFFECT REG RESISTANCE OF TRANSFORMER OHMS	RECTIFIERS (76) DC VOLTAGE INPUT TO FILTER VOLTS	RECTIFIERS (77) DC LOAD CURRENT mA MIN	RECTIFIERS (78) DC LOAD CURRENT mA MAX	RECTIFIERS (79) PEAK CURRENT PER PLATE mA	RECTIFIERS (80) MAX PEAK INVERSE VOLTAGE VOLTS	RECTIFIERS (81) INPUT FILTER	RECTIFIERS (82) SURGE CURRENT AMPS	RECTIFIERS (83) COMMUTATION FACTOR
575A	Mercury Vapor Rectifier	XV2001 through XV2012	Vertical Base Down	—	4.75	5.0	5.25	—	—	—	—	—	—	—	---	—	6.6KV	[illegible]		[illegible]	56	4.45A	2.22A	14.9kV	L	100A	
857-B	Mercury Vapor Rectifier	XV2401 through XV2407	Vertical with Fil. Down	—	4.75	5.0	5.25	—	—	—	—	—	—	—	—	—	7.03KV	60		9.5kV	1.0A	11.6A	35A	10kV	L	168	
4B32	Bias Rectifier	XV2408 and XV2409	Vertical Base Down	—	4.75	5.0	5.25	—	—	—	—	—	—	—	—	—	405	60		450	2.1A	2.6A	2.6A	1400	L	50	
857-B	Mercury Vapor Rectifier	XV2501 through XV2507	← Part of 857-B discussion above																								
5R4-GY	Thyratron Plate Voltage Rectifier	XV2509	Horizontal [illegible]	Paralleled	—	5.0	—	—	—	—	—	—	—	—	—	—	1.5KV	60		2.12KV	3.43	3.43	5.35	2.12KV	R	0.061	
6X4	Rectifier	XV4301	Vertical Base Down	Paralleled		6.3		—	—	—	—	—	—	—	—	—	600	60		270	5	30	41	350	L	0.108	
OB2	Regulator	XV4302 through XV4304	Vertical Base Down	—	—	—	—	—	—	270	30	5	108	—	—	—	—	—	—	—	—	—	—	—	—	—	—
2X2	High Voltage Rectifier - ARC Protection	XV4801	Vertical Base Down	—	2.25	2.5	2.75	—	—	—	—	—	—	—	—	—	1.5KV	60		2.12KV	1.54	1.54	4.85	2.12KV	C	0.06	

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OBJECTIVE

The objective of SCEL-SC form 516, "Summary of Electron Device Operating Conditions", is to insure that the particular electron device and its associated circuitry, operating conditions, environment and use are compatible, in order that the highest degree of equipment reliability may be obtained

GENERAL INSTRUCTIONS

1 The applicable columns of SCEL-SC form 516, "Summary of Electron Device Operating Conditions", shall be filled out as required in these instructions by the equipment contractor and forwarded to the Signal Corps Engineering Laboratories, Fort Monmouth, N J., Attention. Thermionics Branch, ESL, whenever such action is required under the terms of the equipment contract

2 Circuit and/or schematic diagrams shall accompany this form Such diagrams will necessarily show the value of all circuit components and all element connections to each socket will be marked with the corresponding Base Pin No (RTMA) In addition, all such diagrams will be accompanied by an attachment showing the tolerances of all circuit components.

3. In obtaining data on tube operating conditions, only one tube need be installed in any socket, provided test data obtained for that tube is well within the ratings on the appropriate TSS of Specification JAN-1A or Mil E-1B If readings close to the maximum ratings are obtained, additional tubes may be tested, provided the recorded measurement is the average of all the readings taken.

4 On this form shall be tabulated the indicated data as it pertains to receiving and transmitting type tubes, such as electrometer, high frequency triode, tetrode or pentode types, power rectifiers, etc.

5. All items, with the exception of those which are indicated as being for Signal Corps Engineering Laboratories use only, shall be completed by the equipment contractor as specified in paragraph one

6 A separate form shall be submitted for each basic unit of equipment

~~INSTRUCTIONS TO CONTRACTOR FOR~~ FILLING OUT SCEL-SC FORM 516

All items on SCEL-SC form 516 are considered self-explanatory except those mentioned below.

(2) Equipment Nomenclature and Service Use – Give the Joint Communication-Electronic Nomenclature and the contemplated service use

(7) Commercial Nomenclature – List any commercial nomenclature that may have been assigned

(8) Circuit and/or Schematic Diagram No – List the contractor's reference number

(11) Equipment Supply Voltage – State the minimum, nominal and maximum values of the supply voltage at the input terminals of the equipment (item 2) based upon equipment specification requirements.

(12) Equipment Operating Cycle – State the normal anticipated equipment operating cycle as specified in the applicable equipment specification.

(20), (56) Tube Type – State complete type designation (JAN-1A type number, if applicable)

(24), (60) Section – In multi-section tubes, the section having the plate with the highest Base Pin No (RTMA) shall be designated section one, the section having the next highest plate Base Pin No (RTMA) shall be designated section two, etc.

(25), (26), (27), (61), (62), (63) Filament – The readings for min, nom, and max filament voltage shall be measured when the equipment supply voltage (11) is fixed at the min, nom, and max values, respectively.

(31) Fixed Bias Volts – This voltage is measured with respect to ground

(35) Fixed Bias Volts – This voltage is measured with respect to the cathode

(39) Screen to Cathode Volts – Indicate by either an S or B, inserted under the voltage reading, whether this voltage is developed by a series-dropping resistor or a

D POWER RECTIFIER TUBE TYPES

RECTIFIERS														(85)	FOR SCEL USE ONLY ACCELEROMETER MEASUREMENTS		
(75) EFFECT REG RESISTANCE OF TRANSFORMER OHMS	(76) DC VOLTAGE INPUT TO FILTER VOLTS	(77) DC LOAD CURRENT mA MIN	(78) DC LOAD CURRENT mA MAX	(79) PEAK CURRENT PER PLATE mA	(80) MAX PEAK INVERSE VOLTAGE VOLTS	(81) INPUT FILTER	(82) SURGE CURRENT AMPS	(83) COMMUTATION FACTOR	(84) CATHODE WARM UP TIME					REMARKS	(86) FREQUENCY RANGE (CPS)	(87) PEAK TO PEAK AMPLITUDE RANGE (INCH)	(88) ACCELERATION RANGE (G'S)
	7.011	56	4.45A	2.22A	4.45kv	L	100A		.5 min					Three phase full wave bridge with 575's operated in parallel. Data shown for SSB Operation 40 kw input			
	9.5 kv	1.0A	11.6A	35A	10kv	L	168		1 min.	(Filaments connected in Quadrature for 12 [illegible])				Two 3 phase full wave bridge rectifiers with their outputs in series — 6 Tubes deliver 18 KV DC at 35A.			
	450	2.1A	2.6A	2.6A	1400	L	50		0.5 min.					Two tubes in a single phase full wave rectifier.			
											—		—				
	2.12KV	3.43	3.43	5.35	2.12KV	R	0.061		—					Single phase half wave 2 sections of tube paralleled. Rectifier operates in a resistive load.			
	270	5	30	41	850	L	0.108		—					Single phase half wave 2 sections of tube paralleled			
														Voltage Regulator			
	2.12KV	1.54	1.54	4.85	2.12KV	C	0.06		—					Single phase half wave rectifier. Capacitor input filter to a resistive load.			

(11) Equipment Supply Voltage – State the minimum, nominal and maximum values of the supply voltage at the input terminals of the equipment (item 2) based upon equipment specification requirements.

(12) Equipment Operating Cycle – State the normal anticipated equipment operating cycle as specified in the applicable equipment specification.

(20), (56) Tube Type – State complete type designation (JAN-1A type number, if applicable)

(24), (60) Section – In multi-section tubes, the section having the plate with the highest Base Pin No (RTMA) shall be designated section one, the section having the next highest plate Base Pin No (RTMA) shall be designated section two, etc.

(25), (26), (27), (61), (62), (63) Filament – The readings for min, nom, and max filament voltage shall be measured when the equipment supply voltage (11) is fixed at the min, nom., and max values, respectively.

(31) Fixed Bias Volts – This voltage is measured with respect to ground

(35) Fixed Bias Volts – This voltage is measured with respect to the cathode.

(39) Screen to Cathode Volts – Indicate by either an S or B, inserted under the voltage reading, whether this voltage is developed by a series-dropping resistor or a bleeder resistor, respectively.

(42), (43) Grid Current, min., max. – Measured at the supply voltage and supply frequency which results in the minimum or maximum grid-current, respectively.

(45) Duty Cycle – Indicate for pulse applications.

(46) Frequency Range of Operation – Indicate the operating frequency range of the tube in this particular application.

(49) Seal Temp. – Measured in the cavity for certain high frequency tubes, such as lighthouse, pencil, transmitting types, etc.

(52), (85) Remarks – Indicate any tubes provided with forced air cooling or external heater units. Any other pertinent information for which no columns are provided should be shown in this column. Any unusual circuit applications occasioning unconventional tube operation should be explained.

(66) Tube Supply Voltage, min. – Measured with the equipment supply voltage (11) fixed at the min. value, with the filaments hot, and with the VR tube out of the socket.

(69), (72) Surge Current – Measured when the equipment is first turned on.

(81) Input Filter – Indicate by an L or C whether a choke or capacitor input filter, respectively, is employed.

(83) Commutation Factor – Commutation factor is the product of the rate of current decay in amperes per microsecond just prior to commutation and the rate of inverse voltage rise in volts per microsecond just after commutation. If snubbing circuit is used indicate by (S).

For tuning indicator tubes or other special tube types, use blank columns for characteristics not shown in the column headings. For example, target current of tuning indicator tubes, etc.

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Identification of Key Technical Personnel

JAMES O. WELDON

Present Position:

As President and Director of Engineering, Mr. Weldon has closely directed the engineering design and development of most of the high power transmitters which are now in use by the Army, Navy, Air Force, Bureau of Standards and the Voice of America. Under his direction the company has gained a strong position in the field of high power electronics.

Professional Experience:

Mr. Weldon became engaged in radio engineering work for broadcast stations in 1927, acting as Chief Engineer for several stations in the United States.

From 1933 to 1942 he was a consulting engineer and manufacturer of transmitting equipment under the name of the Weldon Engineering Company. One of many of his projects during this period was the design, construction, and the placing in operation in 1938, of a 500,000 watt (carrier power) AM broadcast station, incorporating a high frequency linear power amplifier.

Commencing in 1940, acting in a consulting capacity for the Federal Telegraph Company (now a Division of the International Telephone and Telegraph Company) Mr. Weldon performed the complete electrical design, and assisted in the mechanical design, of a 50 kilowatt and a 5 kilowatt high level plate modulated transmitter, both of which were sold to the Columbia Broadcasting System. They are now in service as the New York City key stations for this System. Station WCBS at Columbia Island, where the 5 kilowatt transmitter serves as an emergency standby for the regular 50 kilowatt operation.

Continuing on a consulting basis for the Federal Telephone and Radio Corporation, Mr. Weldon designed the audio system, power system and control circuits for the 50 kilowatt short-wave transmitters WCBS and WCRC, operated by the Columbia Broadcasting System at Brentwood, Long Island.

In August, 1942, he was employed as Chief Engineer of the Bureau of Communication Facilities, Overseas Branch, Office of War Information, and a few months later was appointed Chief of that Bureau. In this position he had complete charge for OWI of the planning for expansion of the technical facilities for International Broadcasting in the United States, and the installation overseas of a large number of high power broadcasting facilities which were used to carry the Voice of America to the rest of the world during the war. This program involved an annual budget of up to $12,000,000.00.

The expansion of short wave broadcast facilities in this country involved an increase from thirteen transmitters to a total of thirty-six. These transmitters ranged in power from 50 kilowatts to 200 kilowatts, and were operated on the International short wave bands. In addition, approximately four 50 kilowatt standard broadcast transmitters, and two 50 kilowatt and one 100 kilowatt short wave transmitters, were installed by the Bureau in overseas locations.

In September, 1945, with Lester H. Carr, Mr. Weldon organized the partnership firm of Weldon and Carr, Consulting Radio Engineers, doing antenna design and development, allocation work, and a general practice before the Federal Communications Commission, with broadcast station operators and applicants as clients.

Late in 1946, Mr. Weldon came to Dallas, Texas, and organized Continental Electronics Manufacturing Company.

Other Activities:

In January, 1954, Mr. Weldon was awarded a Fellowship in the Institute of Radio Engineers for his work on high power transmitters and their application to International Broadcasting.

His publications include papers on "Very High Power Long Wave Broadcasting Station", (Proceedings of the IRE, August, 1954) and " A 600 Kilowatt High Frequency Amplifier". Mr. Weldon has authored and published many other technical reports both classified and unclassified.

He also holds the following patents:

2,845,529 Protective Circuits - 7/29/58
2,836,665 Amplifiers - 5/27/58
2,871,545 High Voltage Capacitor - 2/3/59

MARK W. BULLOCK

BSc. in Electrical Engineering
University of Nebraska, 1934

Arts & Science Degree
University of Nebraska, 1933

Present Position:

Mr. Bullock, Vice President for Engineering, is responsible for technical and administrative assistance on all projects under development and during production.

Professional Experience:

From 1934 to 1937 he was Transmitter Supervisor for Radio Station KOIL in Omaha, Nebraska. He then became Technical Director for Radio Stations KFAB, KOIL, and KFOR, Lincoln and Omaha, Nebraska and held that position from 1938 until 1944.

Mr. Bullock was employed by the Office of War Information, Bureau of Communication Facilities, from 1942 to 1943, and during that period designed and built the modulator and power equipment for WLWK, a 50 kilowatt International Broadcast facility at Cincinnati, Ohio.

In 1944 he returned as Technical Director and Consulting Engineer to KFAB where as a consultant he performed antenna design work.

Mr. Bullock joined Continental Electronics Manufacturing Company in 1951 as a Senior Engineer. He was promoted to Engineering Manager. Early in 1958, a Production Division was established in Dallas and he was appointed Manager of the Production Division. In 1960 he returned to the main plant as Vice President for Engineering, his present position.

Other Activities:

His professional society affiliations include American Institute of Electrical Engineers, Texas Society of Professional Engineers and the Institute of Radio Engineers where he is serving as IRE Director Delegate-Elect for Region Six during 1961 and 1962.

Mr. Bullock is a registered Professional Engineer in the States of Nebraska and Texas and holds a Radio Telephone First Class License.

Mr. Bullock holds the following patent:
Patent #2,774,808 - "Electrical Equipment Cabinets" - December 18, 1956

The following patent is joint-owned by Mr. Bullock and Mr. Joseph Sainton:
Patent #2,918,631 - "Modulator-Regulator Circuit" - December 22, 1959

W. D. MITCHELL

B. S. in Electrical Engineering
Texas Technological College, 1951

Present Position:

As Administrative Assistant to the Engineering Manager, Mr. Mitchell is responsible for technical and administrative assistance on projects under development.

Professional Experience:

During Service with the U. S. Navy from 1946 to 1947, Mr. Mitchell attended Basic Electronics School in Great Lakes, Illinois and the Aviation Electronics Technical School at Corpus Christi, Texas. After this, he assisted with the construction of the Naval Training Center at Millington, Tennessee, to accommodate the AETM School which was moved from Corpus Christi. Mr. Mitchell joined the engineering staff of Continental Electronics Manufacturing Company in 1951. After the development of many standard AM broadcast transmitters, he was promoted to the position of Project Engineer. As Project Engineer for the VHF and HF transmitters developed for the Signal Corps, Mr. Mitchell was responsible for the development of a 100 KW VHF amplifier and a 600 KW VHF amplifier group. The HF equipment included modification of existing 2 KW and 40 KW equipment and the development of a 600 KW, 4 to 30 megacycle amplifier. In addition to the development of the HF equipment, he was also responsible for the supervision of the installation of this equipment at its operating site, which included adjustment, test and demonstration of performance. The HF equipment was installed at the Department of the Army Transmitting Station, Woodbridge, Virginia during 1958.

Other Activities:

Mr. Mitchell is a registered Professional Engineer in the State of Texas and a Senior Member of the Institute of Radio Engineers.

D. L. Browning

Electrical Engineering,
Southern Methodist University

Present Position:

Development Engineer. In this capacity Mr. Browning is presently in charge of the installation and testing of a 300-Kw HF transmitting facility which is being installed at Ava, New York.

Professional Experience:

Mr. Browning was employed by Continental Electronics as a Student Engineer from 1953 to 1955 while he was attending college. During this time he participated in the development of a 1-kw television transmitter.

From 1955 to 1957 he served in the U.S. Navy as a Radioman and as Shipboard Communications Center Supervisor.

Mr. Browning returned to Continental Electronics as a Student Engineer in 1957. He has participated in the development, installation and testing of the 300-Kw HF Radio Transmitting Set AN/FRT-33 (XC-1) which was installed at Woodbridge, Virginia and in the installation and testing of the 300-kw and 50-kw VHF amplifier groups of Radio Transmitting Set AN/FRT-32 (XC-1) which was installed at Stanford University in California.

L. K. FINDLEY

Mr. Findley attended the University of Minnesota College from 1932 to 1939, when he graduated with a B.E.E. Degree. He worked full time while attending college and was employed by Radio Station KSTP, St. Paul, Minnesota, advancing from Maintenance Engineer to Chief Engineer between 1932 and 1942. In addition, he was employed as Field Engineer by Hector R. Skifter, Consulting Radio Engineer, St. Paul, Minnesota, from 1939 to 1942.

From 1942 to 1944 Mr. Findley was employed by Columbia University's Airborne Instruments Laboratory (O.S.R.D. War Research) as Project Engineer, directing research, mechanical and electrical design, and production engineering on radio and electrical equipment with high and low power, and frequencies from .1 cycle per second to 200 megacycles per second.

In 1944, Mr. Findley worked as Senior Engineer for J. H. Bunnell Company, Brooklyn, New York, developing a high frequency continuously tunable 20 kilowatt broadcast transmitter, and in 1945 he left this position to join Collins Radio Company, Cedar Rapids, Iowa, as Group Engineering Director. In this position he directed development of post-war broadcast transmitters, including a complete line of standard AM and FM broadcast transmitters. He also assisted and directed development of Military Communications transmitters.

Mr. Findley joined Continental Electronics Manufacturing Company in January 1953 as VHF and UHF Project Engineer. Mr. Findley joined the engineering staff of another company in 1957.

L.W. STINSON *

From 1922 to 1924 Mr. Stinson was a Marine Radio Operator, after which he entered the University of Arkansas, graduating E.E. in 1928.

From that date until 1953, Mr. Stinson was Chief Engineer of Radio Station KVOO, Tulsa, Oklahoma, responsible for the construction and installation of transmitters of various power from 1 kilowatt to 5 kilowatts, and through 25 and 50 kilowatts. He also designed and constructed studios, and worked experimentally on television, facsimile, teletype and amateur communications.

On leave of absence from KVOO in 1942 and 1943, with R. M. Willmott, Washington, D. C., he acted as Consultant for the Office of the Chief Signals Officer, designing special equipment for the Signal Corps, including the design and supervision of manufacture of the special receiving system for Command Headquarters, Panama Canal Zone.

In 1945 and 1946, Mr. Stinson was involved in the development and manufacture of the dual diversity receiving system, multiplexing voice and teletype, on Office of War Information International Short Wave Broadcasting Stations.

In 1948 he designed and constructed the FM broadcast station, studios, transmitter and antenna for the University of Tulsa, Tulsa, Oklahoma, sponsored by KVOO, and in 1953 he joined Continental Electronics Manufacturing Company as a Design Engineer.

Mr. Stinson has been an Associate Member of IRE since 1928, and holds an Amateur Advanced Class License.

* Deceased June, 1959

W.M. Busch

Institute of Technology,
Munich, Germany, 1947-1951

Present Position:

Development Engineer. In this capacity Mr. Busch is presently engaged in the design and development of the RF circuitry and amplifiers of a 5,000,000 watt 200 mc pulse transmitter for the Argonne National Laboratory.

Professional Experience:

Mr. Busch was employed as a Consultant Engineer for the design of special broadband receiving systems for LIB - Radio, Munich, Germany, 1952. From 1953 to 1956 Mr. Busch was a member of the staff for the installation and operation of a super power transmitter for the U.S. Information Agency, Voice of America in Munich, Germany. He joined the engineering staff of Continental Electronics Mfg. Company in 1957. Mr. Busch has participated in the development of the 300-Kw HF Radio Transmitting Set AN/FRT-33 (XC-1) and in the design and development of RF filter systems for high power VHF transmitters. He has also been responsible for the design and modification of various control circuits and high voltage protection circuits.

Other Activities:

Mr. Busch is a Member of the Institute of Radio Engineers.

JAMES E. DOHERTY

B.S. in Electrical Engineering
Southern Methodist University, 1950

Present Position:

Mr. Doherty is a Senior Engineer in charge of the installation and test of the AN/FPT-3 high power radar transmitter. His other duties include the design and development of low power RF and pulse exciter equipment in the UHF range and the writing and editing of instruction book and final technical report material.

Professional Experience:

From 1950 to 1951 Mr. Doherty was employed in the Equipment Development Section of the Radio Corporation of America at Harrison, New Jersey. In this capacity Mr. Doherty was responsible for the design and development of equipment for the manufacturing and testing of various types of receiving tubes.

Mr. Doherty was employed by Varo Manufacturing Company in Garland, Texas from 1951 to 1953. In this position he designed and developed electronic regulated power supplies and performed mechanical design work on other electronic equipment.

Mr. Doherty joined the engineering staff of Continental Electronics Manufacturing Company in 1953. He has been responsible for the mechanical and electrical development of low power RF amplifier equipment, DC control circuits and DC amplifier and metering circuits.

Other Activities:

Mr. Doherty is a Senior Member of the Institute of Radio Engineers.

ALBERT J. GEIA

B.S. & M.S. in Electrical Engineering
University of Tennessee, 1956

Present Position:

Mr. Geia is a Senior Engineer. He has been responsible for several projects involving high power equipments in the 400 to 450 mc. range and for theoretical work in connection with other projects.

Professional Experience:

Mr. Geia served as a Studio and Transmitter Operator at Radio Station WDXB in Chattanooga, Tennessee in 1949.

He was employed by the Tennessee Products & Chemicals Corporation, Tennessee Valley Authority in 1950.

He was also Transmitter Engineer and Chief Engineer for Radio Station WUOT at the University of Tennessee in 1950.

He was employed as a Junior Research Engineer at the Engineering Experiment Station of the University of Tennessee in 1955.

Mr. Geia joined the Engineering Staff of Continental Electronics Manufacturing Company after graduation in 1956.

Other Activities:

Mr. Geia is a Member of the Institute of Radio Engineers.